U. S. DEPARTMENT OF COMMERCE
Daniel C. Roper, Secretary
BUREAU OF FISHERIES
Frank T. Bell, Commissioner

THE SALMON AND SALMON FISHERIES OF SWIFTSURE BANK, PUGET SOUND, AND THE FRASER RIVER

By GEORGE A. ROUNSEFELL and GEORGE B. KELEZ

From BULLETIN OF THE BUREAU OF FISHERIES
Volume XLIX

Bulletin No. 27

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1938

For sale by the Superintendent of Documents, Washington, D. C. - Price 30 cents

THE SALMON AND SALMON FISHERIES OF SWIFTSURE BANK, PUGET SOUND, AND THE FRASER RIVER [1]

By GEORGE A. ROUNSEFELL, PH. D., and GEORGE B. KELEZ, M. A.

CONTENTS

	Page
Introduction. By George A. Rounsefell and George B. Kelez	694
The Pacific salmons	695
Fishing districts	695
Development of the fisheries	697
Production and value	699
Need for investigation	700
Acknowledgments	701
Gill net fishery. By George A. Rounsefell	701
Fraser River	701
Early commercial development	701
Relative importance of different species	702
Number of canneries	704
Evaluation of fishing intensity	704
Company licensing system	704
Nationality of the fishermen	705
Number of licenses	705
Units of fishing effort	705
Changes in gill-net boats	707
Changes in the gill net	708
Fishing seasons	709
Changes in location of the canneries	710
Seasonal occurrence of each species	711
Puget sound	712
Localities fished	712
Relative importance of various species	713
Trap fishery. By George A. Rounsefell	713
Reef nets	713
Construction of the traps	714
Number in operation	716
Locations fished	717
Cannery expansion from the trap fishery	719
Season	719
Seasonal occurrence of each species	721
Relative importance of each species and of each district	723
The purse-seine fishery. By George B. Kelez	725
Drag seines	725
Development of the purse seine	726
Early seines	726
Scow seines	726
Development of the modern purse-seine vessel	728
Introduction of power	728
Improvements in vessel design	729
Increase in vessel size	730
Evaluation of fishing intensity	730
Seasonal fluctuations in fleet size	730
Factors affecting seasonal intensity	730
Size of summer and fall fleets on Puget Sound	731
Size of cape seine fleet	733
Changes in composition of the fleet	734
Relation of vessel size to efficiency	736
Seasonal occurrence of each species	740
Puget Sound fishery	740
Cape fishery	741
Fishing seasons in different districts	742
Puget Sound	742
Cape Flattery	744
Relation of fishing intensity to seasonal occurrence	745
Relative importance of each species	747
Puget Sound	747
Cape Flattery	748
The troll fishery. By George B. Kelez	749
Development of the fishery	749
Importance	750
Seasonal occurrence of cohos and kings	751
Sport fishing	753
Sockeye Salmon. By George A. Rounsefell	754

[1] Bulletin No. 27. Approved for publication May 28, 1938.

Sockeye Salmon—Continued.	Page
Introduction	754
General life history	754
Spawning	754
Age at maturity	755
Sockeye rivers of the region	756
Outer coast streams	756
Puget Sound streams	757
Gulf of Georgia streams	757
Migration in salt water	758
Total pack of the Fraser River system	758
Method and locality of capture	759
Indian fishing in the Fraser	759
Extent of the Indian fishery	760
Catch by commercial gear	760
Locality of trap catches	762
Locality of purse-seine catches	762
Changes in abundance of different portions of the run	763
Changes in abundance	765
Average catch per unit of effort with gill nets	766
Index of abundance from traps	767
Purse seines	769
Combined index of abundance	772
Explanation of changes in abundance	772
Abundance of cycle ending in 1934	774
Abundance of cycle ending in 1933	775
Abundance of cycle ending in 1932	777
Abundance of cycle ending in 1931	778
Coho Salmon. By George B. Kelez	781
Introduction	781
Life history	781
Spawning	781
Growth	782
Age at maturity	783
Individuality of populations	783
Locality of capture by different types of gear	784
Catches in various districts	784
Locality of trap catches	785
Seasonal occurrence in various areas	786
Coho Salmon. Changes in abundance	789
Calculation of trap indices	789
Calculation of purse-seine index	792
Trends of abundance	794
King Salmon. By George B. Kelez	795
Introduction	795
Life history	795
Locality of capture by different types of gear	797
Catches in various districts	797
Locality of trap catches	798
Seasonal occurrence in various areas	799
Seasonal occurrence of red and white king salmon	800
Changes in abundance	803
Pink Salmon. By George A. Rounsefell	804
General life history	804
Migration	805
Method and locality of capture	805
Seasonal occurrence in northern and southern districts	808
Changes in abundance between early and late years	808
Indices of abundance from traps	811
Abundance from purse-seine catches	812
Comparison of purse-seine and trap indices	812
Chum Salmon. By George A. Rounsefell	813
General life history	813
Method and locality of capture	814
Seasonal occurrence in northern and southern districts	814
Abundance from Admiralty Inlet traps	815
Abundance from purse seines	815
Summary. By George A. Rounsefell and George B. Kelez	817
The gill-net fishery	817
The trap fishery	817
The purse-seine fishery	818
The troll fishery	818
Sockeye salmon	819
Coho salmon	819
King salmon	819
Pink salmon	820
Chum salmon	820
Bibliography	820

INTRODUCTION

By George A. Rounsefell and George B. Kelez

The decrease in abundance of sockeye salmon in the waters of Swiftsure Bank, Puget Sound, and the Gulf of Georgia has been readily apparent, but no previous attempt has been made to measure accurately this change, nor has the decline of other species been previously demonstrated. The studies included in this report on the seasonal occurrence of each species, and the history and development of each form of gear, were necessary in arriving at logical conclusions as to the causes and extent of the changes in abundance that have occurred. The interrelations of the various species of salmon and the different types of gear in this region are such that the problem cannot be understood unless all of these factors are considered. Not since the general report in 1899, entitled "A Review of the Fisheries in the Contiguous

Waters of the State of Washington and British Columbia," by Richard Rathbun, has this region been considered as an entity.

The region is of considerable extent, including that portion of the high seas in the vicinity of Swiftsure Bank, the Strait of Juan de Fuca, and the narrow inland sea, over 200 miles in length, formed by Puget Sound and the Gulf of Georgia (see fig. 1). Of the numerous tributary streams, only the Fraser River penetrates the Coast Range into the interior. Many shorter rivers, however, such as the Skagit, Snohomish, and Squamish on the mainland, and the Cowichan and Nanaimo Rivers on Vancouver Island, together with a host of smaller streams, also furnish spawning grounds for the salmon of these waters.

THE PACIFIC SALMONS

The Pacific salmons (genus *Oncorhynchus*) inhabiting this region, like the Atlantic salmon (*Salmo salar*) and the steelhead trout (*Salmo gairdneri*), spend varying lengths of time in fresh water after hatching, before descending to the sea where most of their growth is attained. They differ from the Atlantic salmon and the steelhead in that all of the adults, upon returning to fresh water, die shortly after spawning. The adult salmon, returning from the ocean to spawn in the streams from whence they came, form the object of intensive fisheries on Swiftsure Bank, among the inlets and islands of Puget Sound, the Gulf of Georgia, and in the estuary and lower reaches of the Fraser River.

This region has five species of Pacific salmon: The sockeye (*Oncorhynchus nerka*), known as the red salmon in Alaska and as the blueback on the Skagit, Quinault, and Columbia Rivers; the coho or silver salmon (*O. kisutch*), also known as the silverside; the king or spring salmon (*O. tschawytscha*), known as the chinook on the Columbia River and the quinnat on the Sacramento River; the pink or humpback salmon (*O. gorbuscha*); and the chum or dog salmon (*O. keta*), also called keta or fall salmon. In addition to the confusing array of names given above, the immature king salmon are often called blackmouth, a term which is also sometimes applied to immature cohos. In the Gulf of Georgia the immature cohos taken early in their third summer are termed bluebacks.

In size the pinks are the smallest, averaging around 4 pounds. The sockeyes average under 6 pounds, the cohos about 7–8 pounds, and the chums about 9 pounds. The kings are by far the largest, averaging about 22 pounds, with occasional individuals of 60 pounds and upwards.

The pink salmon are unique in that they appear in abundance over the greater part of this region during the odd-numbered years, whereas only a few thousand are taken in the even-numbered years.

FISHING DISTRICTS

The region may be roughly divided into fishing districts, not only geographically, but also in accordance with the types of gear used and the abundance of the various species. Swiftsure Bank is unique in that the vast majority of the cohos and kings caught by trolling are taken there. Here the purse seiners meet the incoming schools of pinks, cohos, and sockeyes that are bound for the Strait of Juan de Fuca, and

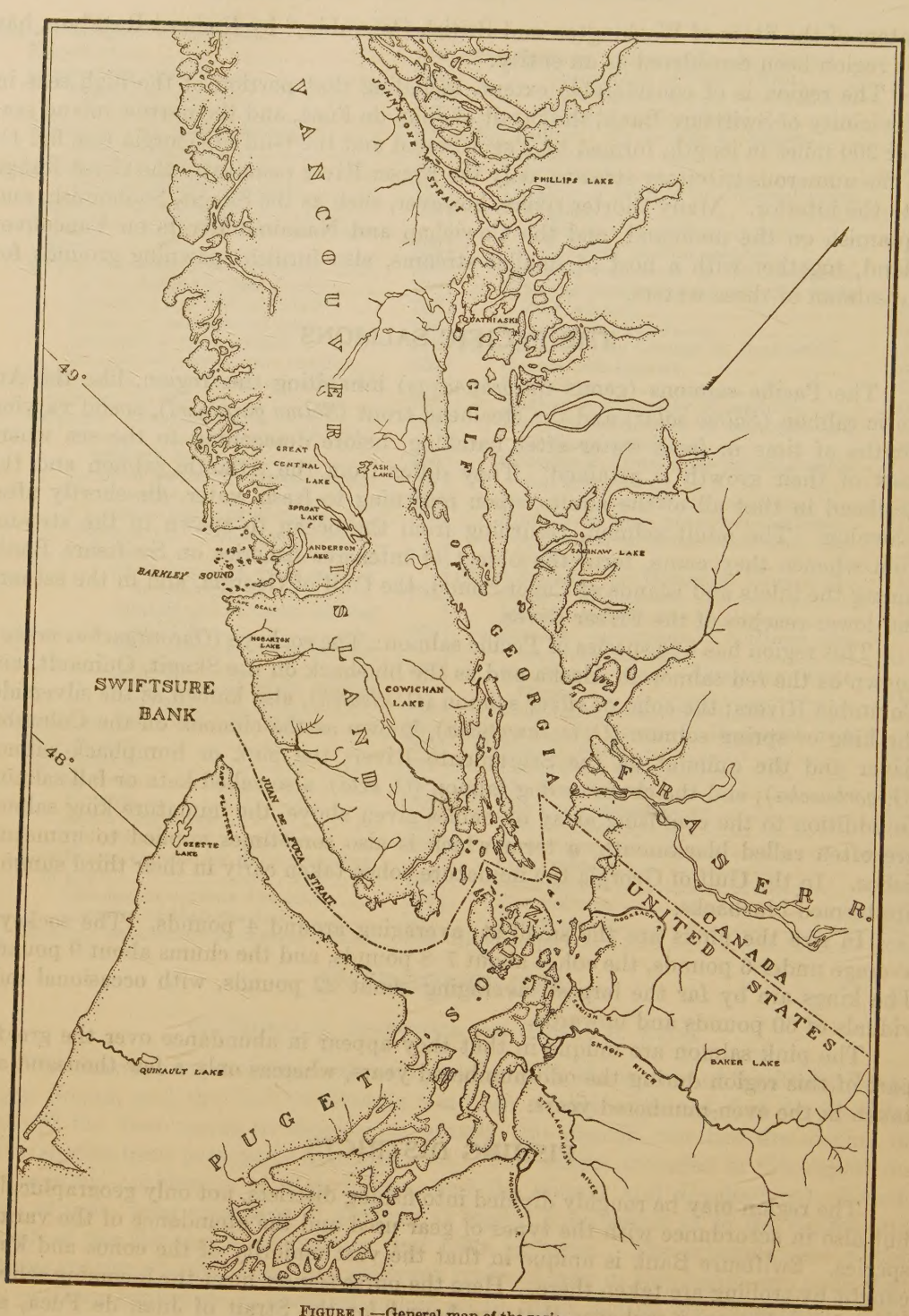
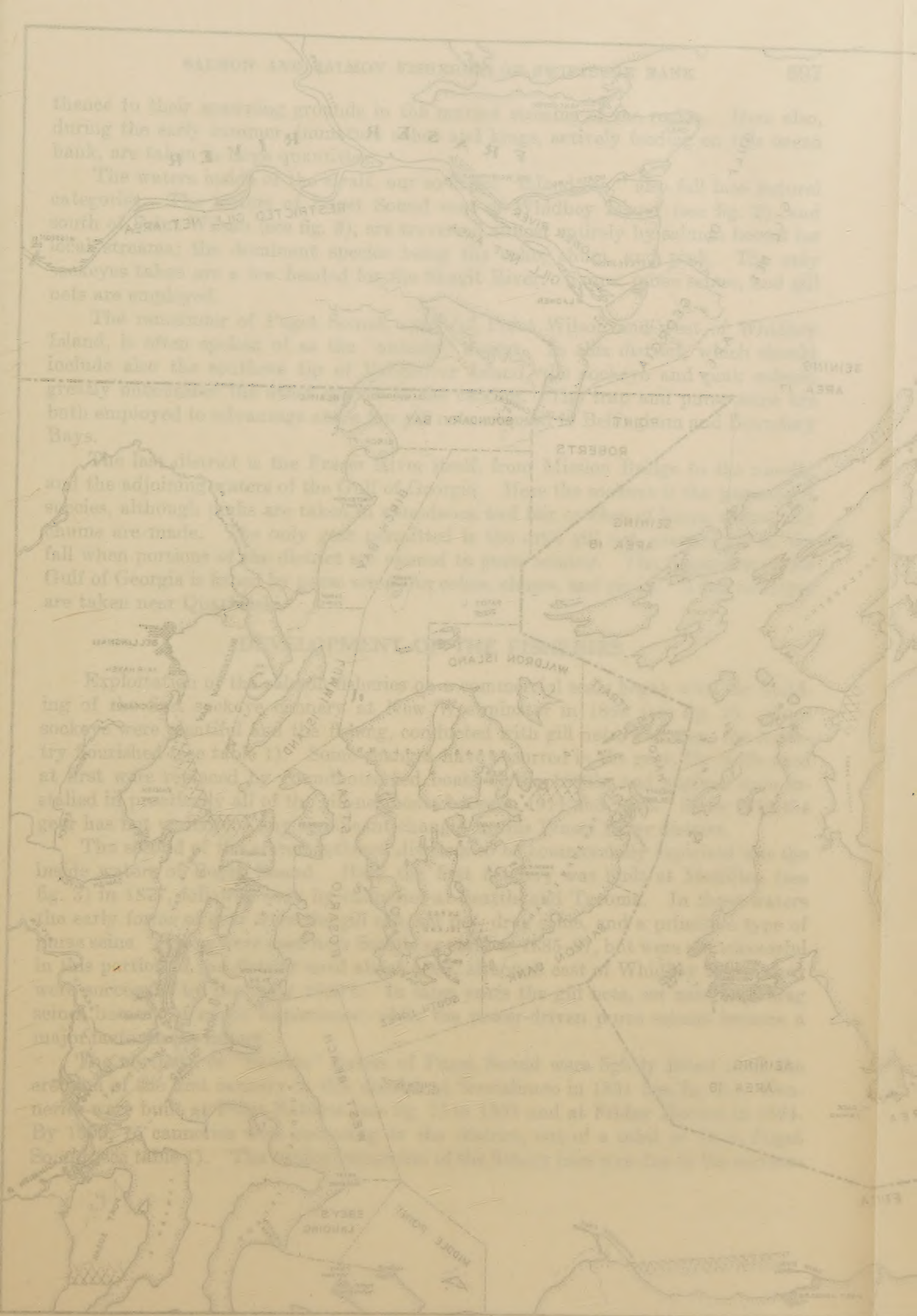


FIGURE 1.—General map of the region.



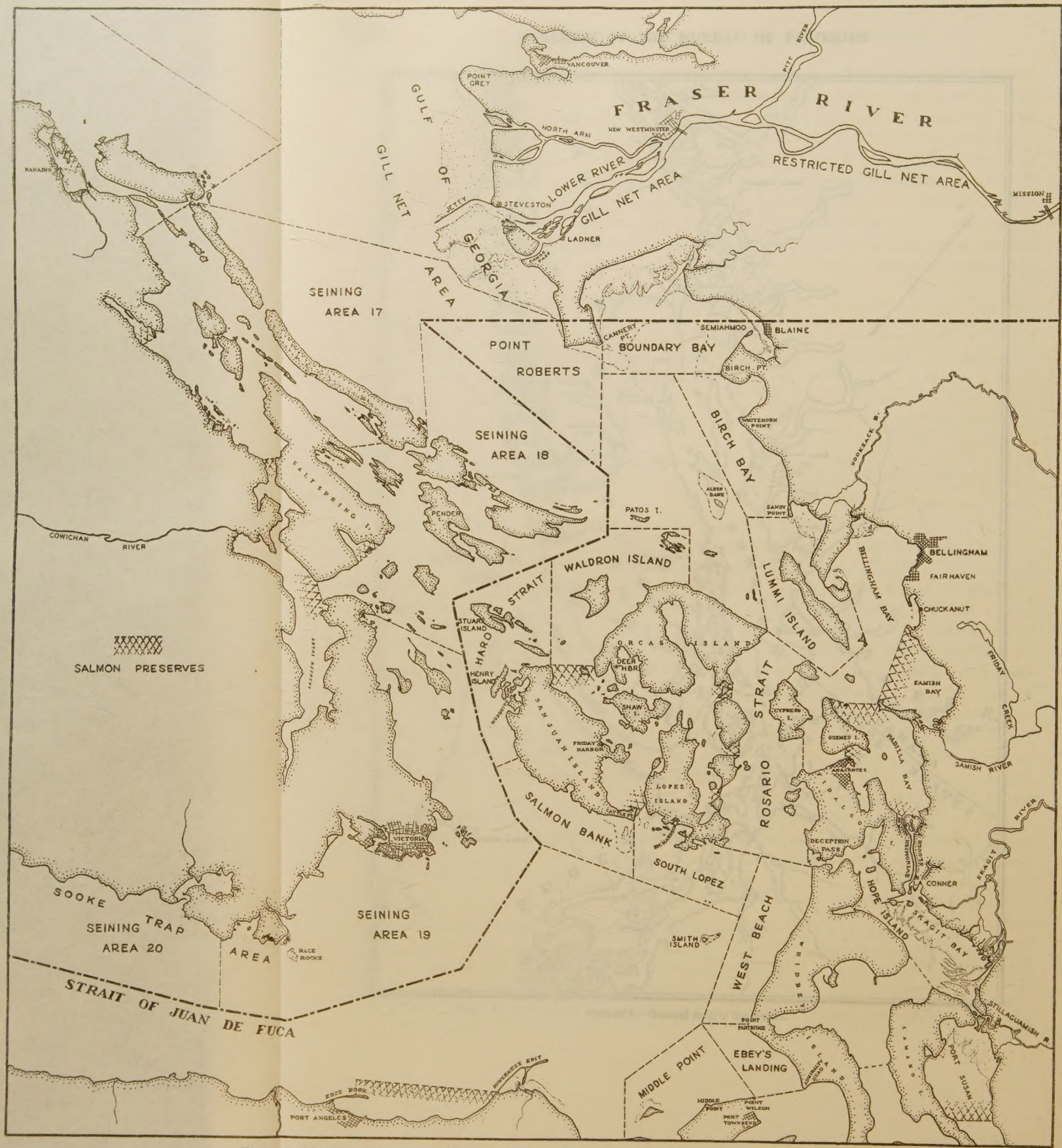


FIGURE 2.—Map of the portion of the region from the Fraser River to Point Wilson, showing the fishing areas.

thence to their spawning grounds in the myriad streams of the region. Here also, during the early summer, immature cohos and kings, actively feeding on this ocean bank, are taken in large quantities.

The waters inside of the strait, our so-called "inland sea," also fall into natural categories. The waters of Puget Sound east of Whidbey Island (see fig. 2), and south of Point Wilson (see fig. 3), are traversed almost entirely by salmon bound for local streams; the dominant species being the coho, chum, and pink. The only sockeyes taken are a few headed for the Skagit River. Traps, purse seines, and gill nets are employed.

The remainder of Puget Sound, north of Point Wilson and west of Whidbey Island, is often spoken of as the "outside" waters. In this district, which should include also the southern tip of Vancouver Island, the sockeye and pink salmon greatly outnumber the other species in the catches. The trap and purse seine are both employed to advantage and a few gill nets are used in Bellingham and Boundary Bays.

The last district is the Fraser River itself, from Mission Bridge to the mouth, and the adjoining waters of the Gulf of Georgia. Here the sockeye is the paramount species, although pinks are taken in abundance and fair catches of kings, cohos, and chums are made. The only gear permitted is the drift gill net, except late in the fall when portions of the district are opened to purse seining. The remainder of the Gulf of Georgia is fished by purse seines for cohos, chums, and pinks. A few sockeyes are taken near Quathiaski.

DEVELOPMENT OF THE FISHERIES

Exploitation of the salmon fisheries on a commercial scale began with the building of the first sockeye cannery at New Westminster in 1866 (see fig. 2). Since sockeye were plentiful and the fishing, conducted with gill nets, was easy, the industry flourished (see table 1). Some changes have occurred in the gear, the skiffs used at first were replaced by roundbottomed boats in the 1890's, and engines were installed in practically all of the gill-net boats between 1911 and 1913. Since 1914 the gear has not undergone any significant changes in this Fraser River district.

The second of the aforementioned districts to be commercially exploited was the inside waters of Puget Sound. Here the first cannery was built at Mukilteo (see fig. 3) in 1877, followed soon by canneries at Seattle and Tacoma. In these waters the early forms of gear were the gill net, set net, drag seine, and a primitive type of purse seine. Traps were used near Seattle as early as 1885–87, but were not successful in this portion of the district until about 1899, although east of Whidbey Island they were successful by the early 1890's. In later years the gill nets, set nets, and drag seines became of minor importance, while the power-driven purse seiners became a major factor in the fishery.

The northern or "outside" waters of Puget Sound were lightly fished until the erection of the first cannery in this district at Semiahmoo in 1891 (see fig. 2.) Canneries were built at Point Roberts (see fig. 7) in 1893 and at Friday Harbor in 1894. By 1900, 15 canneries were operating in the district, out of a total of 19 in Puget Sound (see table 1). The sudden expansion of the fishery here was due to the success-

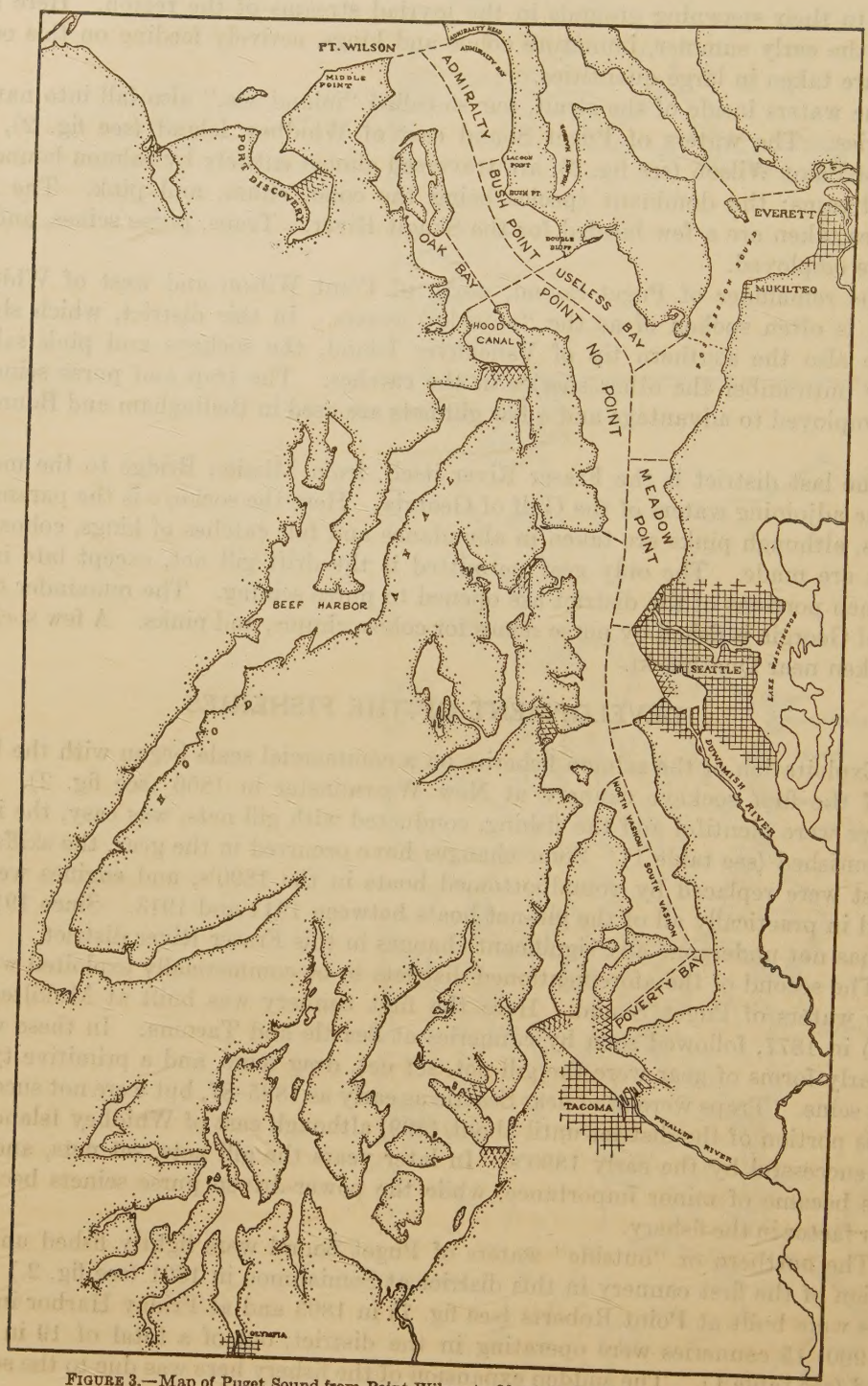


FIGURE 3.—Map of Puget Sound from Point Wilson to Olympia, showing the fishing areas.

ful use of traps in the capture of sockeye Purse seines did not become of great importance in this district until 1907 when power-driven vessels had come into general use.

In the Gulf of Georgia the fishery developed slowly, except for the area near the mouth of the Fraser River. The first cannery in this district was built at Quathiaski in 1904 and canned chiefly cohos, caught by troll in the northern end of the Gulf of Georgia, as well as small quantities of sockeye. Later pinks and chums were also utilized. Except for a small cannery at Pender Harbor in 1906 and 1907, this was the only cannery in this district for several years.

Swiftsure Bank was the last district to be exploited, as the development of this fishery in the open ocean depended upon the increased mobility of power-driven vessels. About 1908 trolling vessels were fishing in the Strait of Juan de Fuca as far as the open sea, and by 1912 the greater part of the fleet was fishing at the cape. Purse-seine vessels also began to fish here by 1911 and, since 1912, a fair share of the fleet has spent a portion of the summer there.

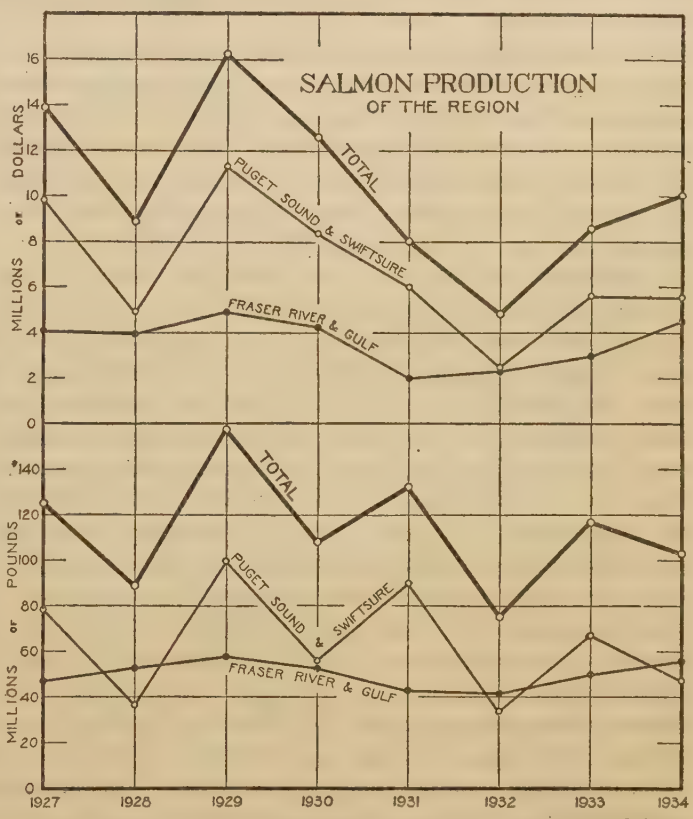


FIGURE 4.—Salmon production of the region in pounds of raw salmon, and wholesale value of the products.

PRODUCTION AND VALUE

Because of variations in economic conditions, and in the abundance of the various species, it is difficult to appraise the value of these fisheries. During the 8-year period, 1927–34, the average annual production was 113,450,000 pounds of raw salmon which had a wholesale market value of $10,400,000. If the 2 worst depression years, 1931 and 1932, are omitted, the averages are raised to 116,660,000 pounds and $11,720,000 (see fig. 4).

However, this region is capable of producing a great deal more wealth than it does at present. By way of illustration one need only refer to the reduced catches of sockeye. From 1898–1913, a 16-year period when the sockeye fishery was flourishing, the average pack of sockeye was 790,000 cases per year, worth on the average $4,930,000 (average price of just over $6.00 per case). During the 8-year period, 1927–34, the sockeye

pack has averaged 229,147 cases, valued at $3,180,000 per year (average price just under $14.00 per case). At present prices the former sockeye pack would be worth $10,960,000 per year—as much as the present fishery for all five species combined—and yet the present sockeye catch only averages about 15,000,000 pounds, or 13 percent of a regional total of 113,000,000 pounds.

NEED FOR INVESTIGATION

Although the entire region should be considered in general as a biological unit, the fact that the salmon are taken on the high seas, and in both Canadian and American waters, has caused each governmental agency to keep only records of the catches landed under their own jurisdiction. Furthermore, during the period covered by this report, these agencies have usually collected only such records as have been necessary for purposes of taxation or general production statistics. Hence, only a few of the existing catch records were of any biological value.

In order to determine such relative factors as the seasonal progression of the runs, or changes in abundance of the various species, it was imperative that catch data be obtained which included the daily landings of individual units of fishing gear. Many valuable records of this type still exist in private hands, although, with the passage of time, a large part of various individual company records have been destroyed or lost when certain companies changed ownership or ceased operation. Accordingly, the authors gathered a vast quantity of these records from both American and Canadian companies which, together with total catch records from the publications of various agencies, have been analyzed in this report.

Such analyses were complicated by the many changes which have occurred during the long period of development of these fisheries. Not only were new fishing areas pioneered, and new types or radical improvements of the old forms of gear developed, but there has been a considerable shift in intensity of the fisheries for some of the species, both for economic reasons and because of changes in abundance. Because these changes directly influenced the exploitation of the resource, the history and development of the major forms of gear have been carefully traced. Differences in fishing locality, seasonal operation, and effectiveness in the capture of the various species of salmon have necessitated the separate consideration of each of the more important forms of gear.

The different species of salmon enter the fishery in varying abundance at certain parts of the season, hence it has been necessary to determine the curves of seasonal occurrence for each species. The changes in abundance that have occurred during the course of the fishery have in the past been measured largely from the total annual production of canned fish, a measure which is especially inaccurate in view of the influence of changing economic conditions, changes in fishing effort, and the obscuring of the decline in certain species by the increase in intensity of the fishery for others. The authors have endeavored to present, for each species, the best measure of abundance possible from the available data. The varying importance of the species in certain districts and in different types of gear, and the differences in production of the major spawning areas have also been treated. The complexity of these problems and the differences in their life histories have made it necessary to consider them, like the major types of gear, in separate sections of the report.

It has been the desire of the authors not only to make the above material available, but to present it in such a way as to provide a thorough understanding of the fisheries of the region and to establish a background which will form the basis for future conservation efforts in the region.

ACKNOWLEDGMENTS

The authors wish to express their appreciation for the splendid cooperation in the furnishing of information and statistics by the following companies: Anglo-British Columbia Packing Co.; The British Columbia Packers; The Canadian Fishing Co.; Francis Millerd; Greatwest Packing Co.; J. H. Todd & Sons; Johnston Fishing & Packing Co.; Kingcome Packers; Nelson Fisheries; Quathiaski Canning Co.; Queen Charlotte Fisheries; Sooke Harbour Fishing & Packing Co.; Alaska Packers Association; American Packing Co.; Anacortes Canning Co.; Astoria & Puget Sound Canning Co.; Beach Packing Co.; Bellingham Canning Co.; Booth Fisheries Corporation; Carlisle Packing Co. (S. P. Kelly); Everett Fish Co.; Farwest Fisheries; Fidalgo Island Packing Co.; Fishermen's Packing Corporation; Friday Harbor Canning Co.; W. A. Lowman; New England Fish Co.; Northwestern Fisheries Co.; Pacific American Fisheries; Puget Fisheries; San Juan Fishing & Packing Co.; Sebastian-Stuart Fish Co.; Icy Straits Packing Co.; Western Fisheries; Western Sea Foods Co. For valuable information and statistics of early fishing on the Fraser River the authors are indebted to Mr. Henry Doyle, of Vancouver. Capt. T. E. Eggers, of Seattle, supplied information of the early fishing on Puget Sound.

The officials of the Fisheries Departments of the Dominion of Canada, the Province of British Columbia, and the State of Washington have extended numerous courtesies, in addition to giving the authors access to their files and records.

GILL NET FISHERY

By George A. Rounsefell

FRASER RIVER

EARLY COMMERCIAL DEVELOPMENT

Gill nets were the first to be developed of the four main types of gear used commercially in this region. Since 1873 they have captured 46 percent of all of the sockeyes taken, as well as large quantities of the other species. The gill net fishery is so inextricably bound up with the Fraser River that its story is largely that of the Fraser itself.

The salting of salmon was begun soon after 1800 by the Northwest Company, later the Hudson Bay Company (Rathbun 1899), which exercised a monopoly of the fishing (Howay 1914), and by 1835 was shipping 3 to 4 thousand barrels of salt salmon each year to the Hawaiian Islands. These early trading companies depended very largely upon salmon for their food supply. Thus, in 1836, the supplies gathered for the upper Fraser River trading posts included 67,510 salmon, 11,941 smaller fishes, 781 sturgeon, and 346 trout (Morice 1904). In 1858 the Hudson Bay Company's license was revoked and its claim of monopoly fell.

The first salmon were canned on the Fraser River in 1863, when Mr. Annandale canned a limited quantity for local use (Doyle 1920). This pre-dates by 1 year the establishment of the first salmon cannery on the Pacific coast by Hapgood, Hume & Company, in 1864, on the Sacramento River. The first real cannery on the Fraser River was built in 1866 at New Westminster. The first cannery on the Columbia River was built the same year at Eagle Cliff. Thus, salmon canning on the Pacific coast started almost simultaneously on three of the largest salmon streams. The first recorded pack on the Fraser River, in 1873 (Rathbun 1899), was 8,125 cases.

Howay (1914), mentions the unsuccessful use of Scotch trap nets in 1864 by the Annandale saltery, and the change to drift gill nets. The gill netting during the earlier years was done by Indian fishermen from canoes and flat-bottomed skiffs. The packs were restricted because of the crudeness and inefficiency of the canning equipment, and because the necessary tinplate had to be shipped around Cape Horn in sailing vessels in advance of the season. Thus, in 1882, because of an unexpectedly large run of salmon, the supply of tinplate became exhausted in the middle of the season and the packers were forced to close down.

RELATIVE IMPORTANCE OF THE VARIOUS SPECIES

In the early development of the Fraser River fishery the sockeye was by far the most important species. The deep color and firmness of its flesh was most important for producing an attractive product with the crude canning methods then in use. Also, sockeyes were tremendously abundant, the run reaching its peak during the summer months when fishing conditions were at their best. So important were they to the canning industry that, for the period before 1900, when accurate records of the number of cases of each species canned were not always available, the total canned pack has often been used to represent the sockeye pack.

In seasons when sockeye were not abundant the canners would often, even during the earlier years, supplement their pack with coho and king salmon. However, when the packers were unable to handle all of the sockeye that the fishermen delivered they could not afford to waste time, effort, or their sometimes inadequate supply of tinplate, to put up a cheaper product. Thus, 1905 was the first of the "big" years of the quadrennial sockeye run to the Fraser River in which as many as 30,000 cases were canned of the other four species combined.

Meanwhile the fishery for king salmon began to attain importance after freezers were built on the Fraser River. The first of these appeared in 1886 and two others in 1887. In early years the canning of king salmon usually began before the sockeye runs made their appearance. Thus, one cannery, in the period from 1887–91, usually started canning king salmon during the latter half of April, more than 2 months before the sockeyes were due to appear. Gradually they commenced operations later in the season until, from 1900–1902, they did not start until after the sockeyes had arrived. There was much variation between individual canneries, however, as to their season of operation.

Since the 1880's a few canneries have remained open, after poor sockeye runs, for the fall fishing. For many years this fishing was confined largely to cohos, and the fall run of king salmon, which are inferior to those running in the spring.

The pink salmon were for a long time considered inferior in value for canning because of their light-colored, soft flesh. However, as the sockeyes became scarcer and a demand for cheaper grades of salmon increased, the pinks eventually became important. The first pack of any consequence on the Fraser River was in 1907 when 63,000 cases of pinks and chums were canned. In 1909, a big sockeye year, only 2,000 cases of pinks were canned, but in 1911, the next pink-salmon cycle, 142,000 cases were packed and the pink salmon had definitely become an important factor in the fishery.

TABLE 1.—*Number of canneries operated in the region*

Year	Fraser River [1]	Victoria and Gulf of Georgia [2]	Puget Sound and Neah Bay [3]	Total	Year	Fraser River [1]	Victoria and Gulf of Georgia [2]	Puget Sound and Neah Bay [3]	Total
1876	3			3	1906	23	4	17	44
1877	5		1	6	1907	18	3	13	34
1878	8		1	9	1908	10	2	11	23
1879	7		2	9	1909	34	3	23	60
1880	7		2	9	1910	21	2	15	38
1881	8		3	11	1911	15	2	20	37
1882	11		3	14	1912	15	2	20	37
1883	13		3	16	1913	35	4	31	70
1884	6		3	9	1914	20	3	22	45
1885	6		3	9	1915	22	3	41	66
1886	11		3	14	1916	21	5	32	58
1887	12		3	15	1917	29	5	47	81
1888	12		4	16	1918	18	5	37	60
1889	15		2	17	1919	14	3	36	53
1890	17		1	18	1920	11	3	11	25
1891	22		2	24	1921	13	3	23	39
1892	22		2	24	1922	10	4	15	29
1893	26		3	29	1923	11	4	18	33
1894	28		4	32	1924	9	4	12	25
1895	33		6	39	1925	10	4	23	37
1896	35		11	46	1926	10	3	14	27
1897	43		12	55	1927	10	3	21	34
1898	49		18	67	1928	8	3	14	25
1899	41		17	58	1929	9	3	21	33
1900	45		19	64	1930	8	3	13	24
1901	49		16	65	1931	7	3	18	28
1902	42		20	62	1932	8	3	10	21
1903	36		19	55	1933	10	3	19	32
1904	25	1	12	38	1934	11	3	21	35
1905	38	2	24	64					

[1] Includes canneries in Vancouver and environs.
[2] Extending north to and including Quathiaski.
[3] Neah Bay is just inside of Cape Flattery. Number estimated from 1878 to 1887, inclusive, except for 1881, which is from Hittell (1882).

Chum salmon were long regarded as a nuisance by the fisherman, although the Indians always used them to some extent, especially in years of poor sockeye runs. In 1897 the Japanese commenced drysalting chum salmon on the Fraser River for the Japanese market, and for use in the Yukon for dog feed. The Report of the Department of Marine and Fisheries for 1899 (1900) says:

> A new feature in the fishing industry this season was the salting for shipment to Japan of 4,000,000 pounds of dog salmon (*O. keta*) by Japanese fishermen. The fish were mostly caught by fishermen when fishing for cohos for the canners, and bought by the Japanese. Formerly this class of fish, when caught, were allowed to go to waste.

In 1900 the canners commenced using chum salmon. The sockeye run was very small and a good price was being offered for lower grades of salmon, so 105,000 cases were canned. Difficulty was experienced in marketing, however, on account

of a large production in other areas, and the chum-salmon pack remained small until 1910, when 52,000 cases were packed. The pack did not again exceed 100,000 cases until 1923.

NUMBER OF CANNERIES

Judging from the number of canneries in operation on the Fraser River or near its mouth each season since 1876 (see table 1), exploitation of salmon increased almost continuously from 1876–98. The great majority of the canneries were built during this 23-year period and the peak was reached when nine new canneries were built in 1897.

The decline in the number of canneries in 1884 was possibly due to unfavorable economic conditions at that time. The Annual Report of the Department of Fisheries for 1884 says:

> There is estimated to be over in Great Britain now—1st January, 1885—in an unsalable condition, . . . , over two hundred thousand (200,000) cases of fall salmon, that will not bring much more than freight, insurance and charges.

In 1901, the large packs both on the Fraser River and in Puget Sound again brought about an oversupply of salmon. The British Columbia Packers Association, which was formed at this time, included 29 of the 49 canneries on the river. The number of canneries in operation was considerably curtailed through this and other combines, especially during the "off" years when a few canneries were sufficient to handle all the catch. During the war years the number of canneries increased somewhat, but at the end of the war it dropped sharply, and there have been less than a dozen since 1921.

EVALUATION OF FISHING INTENSITY

Company Licensing System

In the early years of the fishery the majority of the fishing licenses were taken out by the canneries, who then hired men to fish them on whatever arrangement the company wished to make. At first they usually hired men to fish by the day or month, but later this custom was largely supplanted by the share system in which a certain percentage of the price of the fish, usually one-third, was deducted by the company, which supplied the net and rented a boat for a nominal charge. The independent fisherman was required to fish under his own license. The canneries often hired 2 gangs (2 men in each gang) for each of their boats. Thus, by working in shifts, the license and boat might be used day and night. For instance, Hittell (1882) says of the cannery of Laidlaw and Co. in 1881, "It has 25 boats, which run day and night, with 4 men to each boat."

Of a total of 1,174 gill-net licenses issued in 1893 the companies obtained 909, varying from 27 to 40 licenses per company. Apparently the companies were restricted as to the total number of licenses they might have for 1 company had 27, 7 had 30, 4 had 35, 7 had 36, and 7 had 40.

In 1894 the number of company licenses was reduced by law to a maximum of 20 each for canneries, and 7 for dealers in fresh, frozen, salted, cured or smoked salmon. By 1898 this limit was further reduced to 10, and after 1907 company licenses were abolished.

Nationality of the Fishermen

Because of differences in fishing ability it has been important to a study of the gill netting to note the changes in the nationalities of the fishermen. According to Henry Doyle the fishermen were practically all Indians as late as 1882. The first Japanese fishermen were engaged by English and Company at their Steveston cannery in 1888. Only a few were employed at first, however, and up to 1892 they were not given independent licenses. Doyle estimated that they formed at least one-third of the fishermen by 1895.

The statement by Doyle that in 1882 most of the fishermen, if not all of them, were Indians, is borne out by Hittell (1882) who says that the Delta Packing Company in 1881 had 36 boats and employed 200 Chinese, 150 Indians, and 30 white men. The Chinese, of course, were used as cannery labor, the white men were probably nearly all clerks and mechanics, and the 150 Indians would be about the number required to furnish 2 crews of fishermen (4 men) to each of the 36 boats.

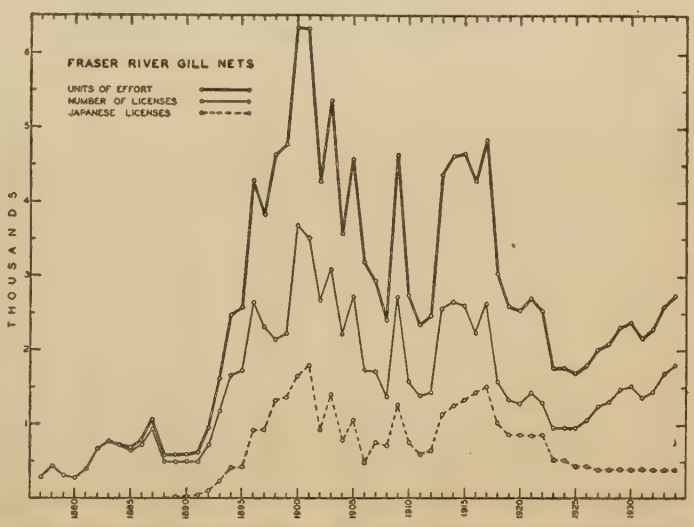


FIGURE 5.—Fraser River gill nets, showing for each year the total number of gill-net licenses issued, the number issued to Japanese fishermen, and the total units of fishing effort. For an explanation of units of fishing effort see text.

From 1900 to date the license registers for individual fishermen have been available at the New Westminster office of the Dominion Fisheries Department. Since 1915 these registers have given the nationality of each fisherman. For previous years we have divided them into three groups: Japanese, Indian, and white, being guided both by the name and residence of each fisherman.

Number of Licenses

The number of licenses issued to each of these three groups of fishermen, plus company licenses—which we have not attempted to segregate before 1900—and special licenses issued since 1908 permitting bona fide residents along the banks of the Fraser River between the New Westminster and Mission bridges to fish only in that area are given in table 2. The figures for the Fraser River, except the totals, for years previous to 1900 were empirically determined from available information.

Units of Fishing Effort

Having made an estimate of the number of each type of fishermen, it has been necessary, in order to obtain the best measure of the intensity of the gill-net fishery

during each season, to determine the relative efficiency of each type. For one company we have records from 1905–16, inclusive, giving the catches of their individual fishermen. During this 12-year period the average annual catch of their Japanese fishermen was 1,782 sockeyes, their white fishermen 1,057 sockeyes, and their Indian fishermen 768 sockeyes (see table 3).

TABLE 2.—*Gill net licenses of the Puget Sound-Fraser River region, 1877–1934*

Year	Fraser River						Puget Sound			Grand total
	Type of license [1]					Total	Type of gill net		Total	
	Company	Individual			Between-bridges license		Drift	Set		
		Japanese	Indian	White						
1877			285			285				
1878			449			449				
1879			304			304				
1880			274			274				
1881			396			396				
1882			666			666				
1883			715	49		764				
1884			645	57		702				
1885			611	44		655				
1886			625	109		734				
1887			615	320		935				
1888		10	323	167		500				
1889		25	308	167		500				
1890		25	308	167		500				
1891		50	283	167		500				
1892		108	373	240		721				
1893		235	558	381		1,174				
1894		417	549	701		1,667				
1895		434	539	731	30	1,734				
1896		926	530	1,130	60	2,646				
1897		928	520	780	90	2,318	422	668	1,090	3,408
1898		1,321	511	690	120	2,642	281	460	741	3,383
1899		1,361	501	710	150	2,722	322	344	666	3,388
1900	393	1,659	555	1,076		3,683	380	330	710	4,393
1901	416	1,805	396	909		3,526	414	369	783	4,309
1902	381	929	583	781		2,674	353	361	714	3,388
1903	343	1,416	477	860		3,096	334	470	804	3,900
1904	232	795	446	742		2,215	438	540	978	3,193
1905	339	1,056	464	915		2,774	348	574	922	3,696
1906	200	494	392	660		1,746	310	618	928	2,674
1907	193	769	270	494		1,726	329	755	1,084	2,810
1908	3	717	175	273	195	1,363	362	836	1,198	2,561
1909		1,263	584	638	243	2,728	366	686	1,052	3,780
1910		766	236	426	148	1,576	403	666	1,069	2,645
1911		607	232	411	146	1,396	459	813	1,272	2,668
1912		655	217	486	72	1,430	377	829	1,206	2,636
1913		1,132	476	843	109	2,560	427	807	1,234	3,794
1914		1,250	333	842	231	2,656	544	458	1,002	3,658
1915		1,332	317	768	199	2,616	512	559	1,071	3,687
1916		1,435	211	437	157	2,240	449	541	990	3,230
1917		1,520	300	570	237	2,627	537	658	1,195	3,822
1918		1,025	106	303	149	1,583	417	646	1,063	2,646
1919		874	56	294	113	1,337	540	686	1,226	2,563
1920		875	36	275	102	1,288	364	439	803	2,091
1921		857	68	359	153	1,437	346	318	664	2,101
1922		871	32	277	116	1,296	119	37	156	1,452
1923		523	26	304	111	964	136	14	150	1,114
1924		523	40	289	117	969	181	10	191	1,160
1925		444	36	357	132	969	391	17	408	1,377
1926		444	53	429	137	1,063	361	11	372	1,435
1927		400	58	619	172	1,249	397	18	415	1,664
1928		400	57	695	151	1,303	353	22	375	1,678
1929		400	73	830	170	1,473	368	23	391	1,864
1930		400	60	863	200	1,523	398	20	418	1,941
1931		400	35	739	184	1,358	319	19	338	1,696
1932		400	26	840	180	1,446	254	8	262	1,708
1933		400	25	1,026	234	1,685	302	9	311	1,996
1934		400	31	1,105	267	1,803	318	12	330	2,133

[1] From 1877 to 1899 the nationalities have been estimated from various notes. The company licenses before 1900 are not separated from the total, and so are allocated amongst the other types. There were no special "between bridges" licenses prior to 1908, so the figures from 1895 to 1899 merely represent a rough estimate of the number of this type of resident up-river fishermen before 1900. From 1900–1907, inclusive, no estimate of these fishermen was made as it was impossible to segregate the nationalities accurately.

TABLE 3.—*Annual catches of sockeyes by white, Indian, and Japanese fishermen at a Steveston cannery, 1905–16, inclusive*

Year	Japanese		Whites		Indians		Cannery license [1]	
	Number	*Average*	*Number*	*Average*	*Number*	*Average*	*Number*	*Average*
1905	114	4,064	72	2,872	29	2,414	9	3,154
1906	46	1,537	77	860	50	550	8	717
1907	132	425	46	234	19	183	9	249
1908 [2]	132	788	42	545	27	370	----------	----------
1909	122	2,393	34	1,437	31	1,102	----------	----------
1910	94	1,270	28	852	10	527	----------	----------
1911	69	824	58	328	11	412	----------	----------
1912	62	1,283	56	611	15	660	----------	----------
1913 [3]	85	3,588	62	1,832	13	1,204	----------	----------
	21	3,546	14	2,365	10	1,142	----------	----------
1914	138	1,053	92	517	29	476	----------	----------
1915	141	435	106	164	27	122	----------	----------
1916	168	178	30	63	20	53	----------	----------
Total	1,324	21,384	717	12,680	291	9,215	----------	----------
Unweighted average	110.3	1,782	59.3	1,057	24.25	768	----------	----------

[1] From 1904–7, inclusive, out of 40 company licencees, 38 were white, 2 Japanese during the summer fishery, and a few Indians were employed for fall fishing.
[2] Includes a very few cohos and some kings.
[3] Two canneries.

From the averages shown in table 3, and the variations in the number of each type of fishermen, it is obvious that in order to obtain a true picture of the intensity of fishing the total number of licenses must be broken into component groups and each group weighted according to an estimate of its efficiency. This has been done by assigning to Indian licenses and "between bridges" licenses a weight of 1.00, to white and company licenses a weight of 1.375, and to Japanese licenses a weight of 2.32. From 1900–1907, inclusive, we have estimated that 150 of the fishermen not falling into other classifications, grouped as whites in table 2, were up-river resident fishermen of the same type that later used the special between bridges license. These are given the same efficiency weighting as the Indian licenses. The total units of effort for each year, estimated on the above basis, have been used in the sockeye section of this report to determine the average annual catch per unit of fishing effort on the Fraser River (see fig. 5 and table 33).

CHANGES IN GILL-NET BOATS

In addition to differences in the efficiency of each license holder, according to his nationality, there have been changes in the form of the unit of gear itself. The first of these to be considered is the change in type of boat used.

According to Greenwood (1917) the fishermen still used a two-oared skiff in 1896, 20 years after salmon canning began. Rathbun (1899, p. 307) says:

> The boats are mostly small skiffs, about 20 feet long, generally manned by two, occasionally by three persons. In recent years the Columbia River boat has been introduced and is now used to a considerable extent in the lower part of the river and outside. Its breadth and centerboard make it much safer for the more exposed places.

Greenwood also says the round-bottomed 30-foot sail boats were introduced "a score of years ago", when 20 were built for the Alliance cannery. This would place their introduction about 1897. However, Rathbun establishes their introduction in the early 1890's.

In 1903 the records for one cannery show that their 25 white fishermen all used round-bottomed boats while their 66 Indian fishermen used 36 round-bottomed boats and 30 skiffs. Since the Japanese all fished on contract no record was kept of their gear, but it is safe to assume that all of their boats were round-bottomed, as they were very progressive fishermen. Among 3,096 licenses issued in 1903 only 477 were for Indians,[2] and it is therefore evident that the transition from skiffs to Columbia River boats was almost complete. After 1905 the records of this company show no skiffs in use.

The introduction of motorpower in gill-net boats, to replace oars and sails, took place soon after the turn of the century. According to old-timers on the river, gasoline engines were used as early as 1902, although only a few were in use until a decade later. Thus records of one of the largest canneries on the river, located at Steveston, show very few gasoline boats in 1909 and 1910. From then on, however, the number increased rapidly and large numbers of engines were installed in 1911–13. By 1914 the change appears to have been almost complete. The data have been insufficient to measure the increase in efficiency brought about by the adoption of engines, but such an increase existed and should be remembered when comparing the catches of the earlier years with those made during and after the World War.

Changes in the Gill Net

The gill-net fishery on the Fraser River is remarkable for the few changes that have taken place in the net itself over a long period of years. There has been no change of any consequence in the length of the net, and the deep nets, used for only a few years, were confined to a small percentage of the fishermen.

In 1882, when the Richmond cannery was built on the North Arm, the nets used in that section of the river were 27 and 30 meshes in depth, 150 fathoms in length, and of 5⅞-inch mesh, according to Charles F. Todd.

The Government regulations that went into effect May 1, 1894, provided for a maximum length of 150 fathoms. Rathbun (1899) says that although there was no restriction upon their depth, custom fixed it at 50 to 55 meshes, though some were shallower. In the years 1903 and 1905, the men fishing on shares for the Imperial cannery used a total of 8 nets of 40-mesh depth, 101 of 45 meshes, 37 of 50 meshes and 1 each of 55 and 60 meshes, placing the average at less than 50 meshes. The records for these years do not give any indication of the depth of the nets used by the Japanese, who formed over 40 percent of the fishermen on the river.

Testimony as to the depth of gill nets is given in the Interim Report of the British Columbia Fisheries Commission (Report of the Fisheries Commission for B. C., 1906, pp. C18–C40), in which one witness, a canneryman, stated:

> This summer I had over 20 boats of Japanese fishing in the river, and there was not one of them with a net of less than 80 meshes.

The same witness says later:

> It is only 8 or 10 years ago that the fishermen commenced to use these extra deep nets * * * I think it is only 4 or 5 years ago since 80-mesh nets were common.

[2] This figure does not include Indians that may have fished on the 343 company licenses.

FIGURE 8.—Brailing crew lifting the spiller of a salmon trap preparatory to brailing. In this operation one side of the spiller is lowered sufficiently to permit a small pot scow to enter the spiller. The side is then raised. Starting at one side of the spiller the crew overhauls the web until the salmon are crowded enough for brailing.

FIGURE 9.—Brailing a salmon trap. The lower end of the heavy net, or brail, is attached to the side of the scow. The upper end is attached to a heavy pipe so that when the brail is lowered over the side of the spiller it sinks quickly. As soon as the brail sinks it is hauled under the densely schooled salmon by the men on the pot scow (in the background). The brail is then hoisted with a winch and the salmon are dumped into the large transporting scow.

From the foregoing it would appear that the depth of the gill nets commenced to increase somewhat after 1899, the last year for which Rathbun gives any information. In 1906 our records for the Imperial cannery give 4 nets of 40 meshes in depth, 52 of 45, 42 of 50, 4 of 72, 4 of 75, and 3 of 80 meshes, so that out of 109 nets only 11 were over 50 meshes in depth. The 1906 records included both share and contract white fishermen, and unless the Japanese fishermen were using radically different gear, our records do not support the viewpoint of the witnesses as to the preponderance of deep nets.

The British Columbia Fisheries Commission also stated:

> We favour the limitation of the length of salmon gill nets to 150 fathoms (300 yards). This was formerly the length of net universally used in the sockeye fishery, but for some years nets double the length, viz., 300 fathoms (600 yards) have been permitted outside the mouth of the Fraser River. To prevent all risk of abuse arising from the alleged use of long nets inside the Fraser River, a length of 150 fathoms is recommended as a maximum limit.

Their statement is at variance with a statement by Inspector C. B. Sword in the Dominion Fisheries Report for 1904, p. 214, in which he says the canners suggest that a gill net longer than the prescribed 150 fathoms should be allowed in the Gulf of Georgia, as the shallower nets in use there would permit handling of 300 fathoms. That the longer nets were not used in the Gulf of Georgia is also the opinion of the cannerymen.

From 1908–30 the size of gill nets in the whole area was restricted to a maximum length of 150 fathoms and a maximum depth of 60 meshes. Since 1930 a maximum length of 200 fathons has been permitted in the Gulf of Georgia.

The size of the meshes in the sockeye nets were restricted as early as 1882, and probably earlier, to a minimum of 5⅞ inches. In 1916 the minimum size of mesh was lowered to 5¾ inches and in 1928 the minimum was abolished.

Fishing Seasons

In studying changes in fishing intensity one must know not only the relative effectiveness of the gear used in different years, but also the length of time during which it was employed and the proportion of the run that occurred during that period. On the Fraser River the closed seasons had little effect on sockeye fishing, especially during the earlier years. At one lower-river cannery the earliest sockeye canning date was July 5, 1887 and 1890, and the latest was August 30, 1888. The shortest season was 26 days in 1885, and the longest was 50 days in 1888; averaging 39 days. The closing date of August 25, effective in most years, had little influence on the pack.

At another lower-river cannery, over the period 1887–1902, the sockeye pack was put up, on the average, in 52 days—from July 5 to August 25. The earliest start was made on June 27, 1896, and the latest on July 13, 1901. The season ended on August 12 in 1887 and on September 6 in 1902.

The sockeye fishing seasons, as far as we have been able to determine from available data, are given in table 4.

TABLE 4.—*Fraser River sockeye fishing regulations*

Year	Closing summer season [1]	Fall season		Week end closed season		Remarks
		Opening	Closing	General	Between bridges [2]	
				Hours	*Hours*	
Before 1878						No regulations.
1878–81	(?)	(?)	(?)	40		No gill netting above tide water—must not obstruct over one-third of channel.
1882–87	Aug. 25			40		Nets 5⅞-inch mesh, minimum.
1888	Aug. 31			40		Nets 150 fathoms maximum length.
1889–92	Aug. 25			40		
1893	Aug. 31			40		
1894–1900	Aug. 25	Sept. 25	Oct. 31	36		
1901	Aug. 31	Sept. 25	Oct. 31	36		
1902	Sept. 6	Sept. 25	Oct. 31	36		
1903	Aug. 31	Sept. 25	Oct. 31	36		
1904–07	Aug. 25	Sept. 25	Oct. 31	36		
1908	Aug. 25	Sept. 16	(?)	42	48	Nets 60 meshes maximum depth.
1909	Aug. 25	Sept. 16	Oct. 7	42	48	
1910	Aug. 25	Sept. 16	Sept. 31	42	48	
1911	Sept. 31			42	48	
1912–14	Aug. 25	Sept. 16	Sept. 31	42	48	
1915	Sept. 31			42	48	
1916	Aug. 25	Sept. 16	Oct. 31	[3] 42	48	Nets 5¾-inch mesh.
1917–20	Sept. 31			42	48	
1921	Sept. 6			42	48	
1922	Sept. 22			42	48	
1923–24	Sept. 30			42	48	
1925	Nov. 21			42	48	
1926–27	Sept. 30			42	48	
1928	Sept. 30			48	48	Mesh limitation abolished.
1929	Nov. 30			48	48	
1930	Sept. 20			48	48	Nets 200 fathoms permitted outside of river.
1931	Sept. 29			48	48	
1932	Sept. 30			48	48	
1933	Sept. 30			48	48	Purse seining Aug. 25–Sept. 30.[4]
1934	Sept. 15	Oct. 1	Oct. 31	48	54	Purse seining Sept. 1–8 and Oct. 1–27.

[1] Closing dates of summer season 1882 to 1903 partly from cannery pack records, opening date July 1 at least as early as 1894.
[2] Fraser River between New Westminster and Mission bridges.
[3] 54 hours weekly closed season during fall of 1916.
[4] Purse seining in area 17, see map.

CHANGES IN LOCATION OF THE CANNERIES

At first the gill-net fishing was conducted inside the river, chiefly from New Westminster to Sumas and beyond, a distance of over 50 miles from the river mouth. At times the canneries received shipments of sockeye that were caught by the Indians with dip nets in Yale Canyon, near Hope, a distance of nearly 100 miles from the river mouth. The first canneries, as a consequence, were located at New Westminster.

Meanwhile the fishermen had discovered that it was possible to make large catches in the lower river and the canneries found it advantageous to be closer to these fishing grounds. Consequently the first down-river cannery was built on Deas Island in 1876, followed by a second in 1878, and a third in 1880. In 1882 two more were built in this area, as well as one each at Steveston and in the North Arm.

The Indian fishermen did not have good boats for fishing outside the river, although they went out at least as far as the sandheads. In 1885 we find the Dominion Report suggesting that the distance between gill nets, while drifting over the sandheads outside the river, should be increased from 250 to 400 yards. That they did not, as yet, venture far from the river mouth is attested by the Dominion Report

for 1887 which states that the fishermen go out only as far as the lightship, 4 or 5 miles from land.

Table 1 gives the number of canneries operated annually from 1876 to 1934. For nearly 20 years the proportion of the canneries located at New Westminster declined, while the proportion near Steveston and Ladner continued to rise. The few remaining canneries were either at the river mouth, in the North Arm, or entirely outside the river proper.

The canneries at Ladner reached their peak in 1885, when half the total number operating were located there, and have since declined steadily to a point of little consequence. Many ascribe much of this decline to the fact that the fish have entered the river through Canoe Pass in decreasing numbers since the driving of traps at Point Roberts. The decline may possibly be further ascribed to the silting up of Canoe Pass and the change in the main channel at Woodwards Slough, effected during the flood of 1894, which made it difficult to reach most of the canneries with large boats.

SEASONAL OCCURRENCE OF EACH SPECIES

Seasonal occurrence is of prime importance in any fishery wherein more than one species is taken, as the intensity of fishing for a species is not governed by its abundance alone, but by a combination of factors, such as the relative abundance of the several species at any time during the season, as well as the relative prices.

In determining the seasonal occurrence for sockeyes, data for 1,982,735 fish taken in 30,706 gill-net deliveries were used, covering 3 complete 4-year cycles, 1898–1909, inclusive. The occurrence shown in these early years was considerably different than that shown in the last three cycles, 1923–34. This difference is treated in the sockeye section of this report (see page 754).

The king salmon curve is derived from 102,123 fish taken in 26,193 deliveries over a 5-year period, 1929–33.

For pink salmon 8 years are represented, all of the odd-numbered years from 1915–33, except 1917 and 1921; the data totaling 597,774 fish in 15,581 deliveries.

The coho curve is also based on 8 years' data, 1904, 1905, and 1929–34, and represent 155,957 fish in 22,117 deliveries.

The chum-salmon curve represents only 3 years, 1932–34, but is quite representative of those particular years, comprising 263,703 fish from 10,608 deliveries.

In analyzing these data the average catch per delivery for each 7-day period was computed for each year and then given equal weight in determining the average curve for all years (see table 5).

Table 5 shows that the period over which one or more species can be taken in some measure of abundance extends from June 24 (week ending June 30) to November 17; 21 weeks, or 147 days. As mentioned above, in earlier years the season was very much shorter, corresponding largely to the more abundant portion of the sockeye run.

The sockeye and pink-salmon runs, which overlap to a slight extent, are both of short duration. Approximately 79 percent of the pinks are caught in 4 weeks, September 2–29, and 83 percent of the sockeyes are taken in the 5 weeks from July 22–August 25.

TABLE 5.—*Seasonal occurrence in Fraser River gill nets*

Week ending—	Percentage occurrence					Week ending—	Cumulative percentage occurrence				
	Sockeye	King	Pink	Coho	Chum		Sockeye	King	Pink	Coho	Chum
June 30		3.73				June 30		3.73			
July 7		5.17		.083	0.42	July 7		8.90		0.83	0.42
July 14	4.15	5.21	0.37	.92	.42	July 14	4.15	14.11	0.37	1.75	.84
July 21	5.68	6.53	.46	.84	.42	July 21	9.83	20.64	.83	2.59	1.26
July 28	9.90	5.24	.43	.87	.42	July 28	19.73	25.88	1.26	3.46	1.68
Aug. 4	18.24	5.36	.98	.84	.42	Aug. 4	37.97	31.24	2.24	4.30	2.10
Aug. 11	24.95	7.45	1.42	.99	.42	Aug. 11	62.92	38.69	3.66	5.29	2.52
Aug. 18	20.21	7.11	1.28	.87	.51	Aug. 18	83.13	45.80	4.94	6.16	3.03
Aug. 25	10.12	8.06	2.66	1.11	.47	Aug. 25	93.25	53.86	7.60	7.27	3.50
Sept. 1	6.75	10.04	5.65	2.65	.56	Sept. 1	100.00	63.90	13.25	9.92	4.06
Sept. 8		7.35	14.73	5.96	.58	Sept. 8		71.25	27.98	15.88	4.64
Sept. 15		8.40	31.40	14.64	.75	Sept. 15		79.65	59.38	30.52	5.39
Sept. 22		5.19	18.25	12.52	1.18	Sept. 22		84.84	77.63	43.04	6.57
Sept. 29		3.90	15.84	14.57	2.86	Sept. 29		88.74	93.47	57.61	9.43
Oct. 6		3.77	3.37	13.69	6.69	Oct. 6		92.51	96.84	71.30	16.12
Oct. 13		3.38	2.27	9.43	11.66	Oct. 13		95.89	99.11	80.73	27.78
Oct. 20		1.87	.54	6.72	13.01	Oct. 20		97.76	99.65	87.45	40.79
Oct. 27		2.24	.37	7.38	13.37	Oct. 27		100.00	100.02	94.83	54.16
Nov. 3				2.29	28.46	Nov. 3				97.12	82.62
Nov. 10				1.34	9.58	Nov. 10				98.46	92.20
Nov. 17				1.53	7.81	Nov. 17				99.99	100.01
Number in sample	1,982,735	102,123	597,774	155,957	263,703						
Number of catches	30,706	26,193	15,581	22,117	10,608						

The chum season is of almost as short a duration, 76 percent being taken in the 5 weeks from October 7–November 10. The coho season is somewhat more protracted, only 65 percent being taken in the 5-week period from September 9–October 13, and 7 weeks being required, September 9–October 27, to take 79 percent of the catch. The king salmon run rather steadily over a long period, 11 weeks, from July 1–September 15, being required to cover 76 percent of the run.

Fifty percent of the sockeye catch has been made by about August 7 (see table 5). The pinks do not reach the 50 percent mark until about September 12, a difference of 36 days. This is followed about 2 weeks later by the cohos, which reach the 50-percent mark on September 26. Another month usually elapses before 50 percent of the chum run has passed. The king salmon run slowly but steadily and reach the halfway point about August 22.

PUGET SOUND

LOCALITIES FISHED

Gill nets have been employed in Puget Sound since the earliest days of the fishery, but have never attained the importance that they have on the Fraser River. There are two reasons for this: First, in the clear waters of Puget Sound gill nets can be used only at night, as the fish avoid them in daylight; and second, it is difficult to compete with other forms of gear.

The gill nets employed were of two kinds, drift and set, and, as their name implies, one was used adrift and the other anchored. They were used chiefly in a few localities such as Skagit Bay and Skagit River, the estuary of the Snohomish River, and off the mouths of the Nooksack and Samish Rivers. A few were used in other localities, especially south of Point Wilson, among the San Juan Islands and in Boundary Bay.

The addresses of the drift net licensees in 1899, from the State of Washington Fisheries Department files, showed that of 322 licenses issued, 154 were taken out in

areas south of Point Wilson, 78 from Seattle, 38 from Tacoma, 26 from Hood Canal, and 12 from scattered localities. More than one fourth, or 86, were from Skagit Bay and the Snohomish River. Of the remainder 1 was from Port Angeles, 5 from the San Juan Islands, and 76 from Bellingham and Boundary Bays.

A second check was made, for the year 1901, of both drift and set gill nets, and it was found that out of 414 drift gill net licenses, only 63 were from Boundary Bay and the San Juan Islands. Out of 369 set net licenses 15 were from the San Juan Islands and none from Boundary Bay. It is evident that gill nets played a very minor role in the sockeye fishery in Puget Sound.

The set nets were employed chiefly in river mouths, and especially in the Skagit, Snohomish, Duwamish, and Puyallup. A few were used away from the river mouths at such places as Open Bay on Henry Island, Andrews Bay on San Juan Island, and along the northwest shore of Orcas Island.

There is some confusion as to the number of set nets operated, and as to their location during the earlier years. This is because a set net license was sometimes bought merely to hold a trap location during a year when it was not desired to drive the trap. The license fee for a trap was from 4 to 10 times as much as for a set net.

No accurate estimate of the numbers of the different species taken by the gill-net fishery is available for early years, but the fishery was essentially the same then as today, except for the areas around Seattle and Tacoma, and the head of Puget Sound, where the salmon runs declined several years ago.

RELATIVE IMPORTANCE OF VARIOUS SPECIES

The set nets, fishing chiefly in the river mouths, caught mostly cohos and kings. In the 4 years from 1917–20, inclusive, they caught, on the average, 5.8 percent of the cohos and 3 percent of the kings taken in Puget Sound. They took but 1.3 percent of the chums and negligible quantities of pinks and sockeyes. After the formation of the Washington State Fishery Board in 1921, set nets ceased to be a factor in the fishing because of their subsequent strict seasonal regulation and their removal, by law, from the rivers.

The drift gill nets, fishing in the more open waters, caught a greater variety of salmon than the set nets. During the 18-year period 1917–34, inclusive, they took, on the average, 12.1 percent of the kings, 8.9 percent of the cohos, 4.9 percent of the chums, 1.1 percent of the sockeyes, and 1 percent of the pink salmon caught in Puget Sound.

TRAP FISHERY

By George A. Rounsefell

REEF NETS

Reef nets, being the forerunners of the traps, will be considered first. They were used almost exclusively by the Indians, deriving their name from the kelp-covered reefs on which they were fished. Originally made from the fiber of cedar bark or roots, they were changed to cotton twine when it became available. According to Rathbun (1899) a reef net consisted of a piece of webbing, varying more or less in size, but averaging perhaps 36–40 feet long by 25–30 feet across, the mesh being about 3½ inches.

To fish a reef net a channel was cut through the kelp. The net was suspended between two canoes, anchored at both the sides and bows, with the forward end of the net sloping downward and the rear end curving back upward to the surface. In deep locations strands of rope were sometimes strung across in front of the net and below it, to lead the salmon closer to the surface. The nets were fished when the tide was running strongly, but a tide of over 5–6 knots per hour was considered too fast for fishing. Reef net crews often had two locations and fished them at different stages of the tide. A lookout was stationed in the bow of each canoe and when a schoolof salmon passed over the net they signaled for it to be lifted. The net crews immediately let go the side anchor lines and, since the bow anchors were placed close together, the canoes were swung toward each other by the current. At the same time the forward edge of the net was swiftly lifted, enclosing the salmon in a bag from which they were dumped into the canoes.

Because of the manner in which these nets were operated, only a few localities were well suited to this type of fishing. One of the principal reef-netting grounds was off the southeastern point of Point Roberts, before that region was disturbed by the introduction of traps. Another excellent ground was along the western shore of Lummi Island, but the introduction of traps here diverted the salmon from these reefs. Other grounds, of lesser importance, were along the south shore of Lopez Island, the west shore of San Juan Island, the east and west shores of Stuart Island, and at Point Doughty on Orcas Island.

The number of these nets in the earlier years of the fishery must have been considerable, as Rathbun says that 15 to 20 nets were formerly fished at Point Roberts, 16 operating there in 1889. By 1894 the string of traps had destroyed the advantage of this reef for nets. Wilcox (1898) lists 25 reef nets in Whatcom County and 14 in San Juan County in 1894. As late as 1901 there were 27 reef nets licensed, 15 to Lummi Island Indians and 12 to residents of the San Juan Islands. Because of the amount of labor involved, and the scarcity of favorable fishing locations, this gear was gradually supplanted, and only about a dozen have been used each year for the past 20 years.

According to Rathbun the reef-net fishermen confined their attention almost exclusively to sockeyes, taking only a few king salmon. However, in late years they have taken more of the other species, especially pinks and cohos. A day's catch has declined until, in recent years, it has rarely amounted to more than a few hundred salmon, but this decrease has been due largely to the fact that the more favorable locations have been rendered useless by traps.

CONSTRUCTION OF THE TRAPS

The trap fishery, which was abolished after 1934 in Puget Sound by the passage of an initiative measure in the State of Washington, was the second of the four main types of gear to attain prominence. From 1873–1934 they have taken 37 percent of the sockeyes caught in the region, as well as enormous numbers of the other species.

Trap nets were tried at Point Roberts some years earlier than at other places, the first trap being built in 1880 by John Waller at Cannery Point, Rathbun (1899), (see fig. 7). Several years elapsed before the fishermen discovered the most desirable

FIGURE 6.—Modern Fraser River gill-net boat. These round-bottomed motorized boats are very seaworthy, being relatively independent of the vagaries of the weather. They are more efficient than the skiffs in use during the earlier years, or the round-bottomed boats in use before motors were installed.

FIGURE 7.—View from Cannery Point, on Point Roberts, showing the cannery established there in 1893. Note the 10 traps in the background. The trap nearest the cannery is approximately on the original trap location in Puget Sound, first established by John Waller in 1880.

locations for intercepting the salmon runs, and before they learned to build their traps sufficiently strong to withstand the storms that occasionally swept all exposed locations.

The first traps consisted essentially of a barrier, or "lead" of webbing hung from a row of driven piling, which diverted the passing fish into a pen, or "crib," similarly constructed. Although patterned after the pound nets of the Great Lakes, with a crib, heart, tunnel, and lead, they were built with much heavier piling which was usually strengthened by having the pilings bound together with a capping of timbers, lashed on with cables. At first the heart was merely two rows of piling that formed a V with the lead pointed toward the bottom of the V. The fish followed the lead, which usually extended out from shore, until they found themselves between the lead and one of the outstretched arms of the heart. Continuing farther they swam through a narrow opening, or tunnel, into the crib.

By 1895 the traps were much improved. The heart was often partially closed at its base, so that if the fish failed to enter the tunnel into the crib, they would, on circling back, find themselves in a semienclosure pointing toward the tunnel. A few traps had double hearts to minimize the chances of escape, and some had a leadlike extension, the forerunner of the "jigger" often employed on later traps. The jigger was essentially a supplementary lead consisting of a row of pilings connecting at about a right angle with the arm of either side of the heart, depending on the direction from which the fish usually approached the trap, and extending out toward deeper water, with the pilings driven to form a hook on the far end. The purpose of the jigger was to direct back to the lead such fish as passed the opening into the heart.

The cribs in several traps measured by Rathbun were rectangular but not always square in shape, ranging from 35–80 feet on a side, and were driven in water from 3–9 fathoms in depth. The catches were sometimes much larger than could be handled by the canneries at once and, while a large catch might be held in the crib for several days, such accumulation prevented continuous fishing during a period when the salmon might be running best. To meet this contingency, an adjunct to the crib, called a "spiller," was devised and appeared to be coming into general use. It was, in fact, an additional crib, square in shape, and connected with the first by means of a tunnel, through which the surplus fish of any catch could be driven.

The netting on the earlier traps was cotton twine, usually of 3-inch mesh in the crib and heart and from 3½–4 inches in the lead. Galvanized wire netting, in place of cotton, was experimentally used for the hearts and leads at Point Roberts in the late 1890's, Rathbun (1899).

The modern fish trap differs from the majority of those described by Rathbun in several respects. All of the trap, except the lead, is now customarily capped. If no capping is used the piles are tightly connected with a heavy wire cable to which the netting is attached to prevent sagging. All netting, except the spiller, is of galvanized wire which is cheaper and much more easily kept clean of seaweed and floating debris.

All traps use a spiller of tarred cotton web. As a general rule the spiller is 40 feet square, and the pot is usually the same. If a trap fishes very well a second spiller is sometimes driven on the opposite side of the pot to take care of the surplus fish.

A spiller is so placed that the fish, which enter the trap with the tide and then turn and swim against it, are led into the spiller through a narrow web tunnel which can easily be closed when the current is running in the opposite direction. Two spillers thus have a big advantage over one in that each one can be filled in turn, unless the trap is in an eddy where the current does not reverse itself with the tide. The pot aids in the fishing as the fish would not readily pass from as large a chamber as the heart directly through the narrow tunnel leading to the spiller, but the salmon are removed only from the spiller.

The construction of the earlier traps was modified to some extent when certain regulations were put into effect. In 1897, the length of a trap lead was restricted to 2,500 feet, and it was further provided by law that there should be an end passageway of at least 600 feet, and a minimum lateral passageway of 2,400 feet, between all traps.

These regulations had the effect of preventing a complete blockade of a whole area. For instance, in 1895 a string of three traps, each one connected with its neighbor, extended in a southeasterly direction off Cannery Point, the southeast tip of Point Roberts, for a mile. Two other connected traps near the international boundary extended for four-fifths of a mile. Such long strings of traps were not uncommon, and the law advanced conservation by breaking them up.

Another law, passed in 1897, prohibited traps from operating in water over 65 feet in depth. However, this law was not observed for several years. In 1913, soundings by the State Fish Commissioner (Washington State, 24th and 25th reports, 1916, p. 36) revealed 11 traps operating in water exceeding the legal depth by 1½–27 feet, The owners admitted having driven these traps in the same locations for 12 years, but changed them to conform with the law.

NUMBER IN OPERATION

The total number of traps operated each year in Puget Sound has been rather difficult to obtain owing to the fact that a trap need be driven only once in 4 years in order to hold a location. Furthermore, where the driving of one trap would tend to lead fish away from another it has been the general practice among companies to drive the one location for fishing and to hold the other by driving a "dummy" trap there at least once every 4 years. A dummy trap was very poorly constructed, and hung chiefly with old, worn-out gear. The object was merely to comply with the law, the dummy not being expected to catch more than a few dozen fish.

In addition to these dummy traps there have always been some traps of an experimental nature, especially in years of abundant runs and good prices. Many of these locations have been driven but once, others have been tried from time to time.

The efficiency of the traps has not varied as much as the number in operation from year to year might seem to indicate, since the best locations are practically always fished, and many of the extra traps, added during years of abundant runs or high prices, are driven in inferior locations.

The number of traps in operation, exclusive of dummies, is given in table 6. Between 1895 and 1900 the traps doubled in number three times, reaching a peak of 163 in 1900. During this first great expansion many inferior locations were tried and later abandoned, as shown by the lessened number in all years except for those of the

big sockeye runs. During the World War the number of traps remained high even during years of poor runs owing to the high prices of salmon, but immediately thereafter the number fell off sharply and never fully recovered.

The number of traps has been reduced to a slight extent by regulations closing certain areas to fishing. In 1921 the State fishery board set aside certain areas as salmon preserves, but they were areas that had been without regular traps for several years. The San Juan Island preserve had had a few traps at times, especially on Shaw Island, but none of them had been successful.

In 1924 the Hood Canal preserve, which was created in 1921 to protect the lower end of Hood Canal, was extended to take in nearly all of the canal. Two or three traps that had been operating in the fall, chiefly for chum salmon, were thus removed. In the same year traps were prohibited in the Hope Island area, thus removing about a dozen traps catching chiefly Skagit River salmon. However, this prohibition was modified the following year.

TABLE 6.—*Number of salmon traps operated from 1893–1934, exclusive of dummy traps*

Year	Traps operated in Puget Sound [1]			Traps with data before 1915	British Columbia traps	Total	Year	Traps operated in Puget Sound [1]			Traps with data before 1915	British Columbia traps	Total
	Regular	Experimental	Total					Regular	Experimental	Total			
1893			[2] 13	3		13	1914			116	71	[8] 10	126
1894			[3] 19		1	20	1915	121	27	148		[8] 10	158
1895			[4] 21	11	2	23	1916	96	14	110		4	114
1896				26	2		1917	121	32	153		7	160
1897			[5] 71	35	4	75	1918	98	11	109		[8] 11	120
1898	39	6	45	32	3	48	1919	101	13	114		[8] 8	122
1899	98	14	112	76	3	115	1920	71	8	79		[8] 8	87
1900	130	33	163	74	3	166	1921	91	5	96		8	104
1901	140	9	149	88	3	152	1922	62	1	63		4	67
1902	105	37	142	82	3	145	1923	90	6	96		6	102
1903	104	2	106	67	3	109	1924	68	3	71		4	75
1904	75	4	79	44	1	80	1925	104	13	117		5	122
1905	137	1	138	70	[7] 17	155	1926	86	5	91		6	97
1906	88	8	96	61	[9] 10	106	1927	97	3	100		5	105
1907			[6] 98	60	[7] 12	110	1928	86	2	88		5	93
1908			80	49	[7] 12	92	1929	116	14	130		6	136
1909			152	76	[9] 15	167	1930	102	9	111		6	117
1910			93	57	[9] 10	103	1931	93	5	98		4	102
1911			111	68	[9] 10	121	1932	47	1	48		4	52
1912			110	66	[8] 10	120	1933	80	3	83		5	88
1913			168	84	8	176	1934	84	8	92		5	97

[1] 1898–1906 partly from State license files at Auburn.
[2] At Point Roberts only, Rathbun (1899).
[3] Partly estimated from Rathbun (1899).
[4] Rathbun (1899).
[5] Fidalgo Island Packing Co. records.
[6] 1907–14 estimated. Number for which we had data estimated as 61 percent of traps operated, as from 1901–06 (except 1905), when it varied from 56–64 percent. In 1905 twice as many operated and this was used for 1909 and 1913.
[7] Partly from Pacific Fisherman.
[8] Number licensed.
[9] Estimated.

LOCATIONS FISHED

Because of the sketchy nature of the available data no attempt has been made to give accurately the number of traps operating in each area prior to 1898. Traps were first tried at Point Roberts in 1880, but could hardly be considered a success until 1891. In the few years from 1891–97 traps were driven in numerous localities throughout Puget Sound, but mostly without much success. The locations that proved successful were continued, and for the others only a few records are available.

The number of traps fishing in each locality since 1898 is shown in table 7.[3] It is apparent that while the trap fishery was widespread its use was emphasized only in those few localities where trap sites could be favorably situated to intercept the salmon runs, and where there was a depth and a bottom suitable for driving. Where these conditions were well satisfied, as in Boundary Bay, the number of traps was large. In some areas, like the Salmon Banks or Rosario Strait, the fish were present, but suitable places for driving were scarce, and few traps were constructed.

TABLE 7.—*Number of traps fishing in various localities, 1898–1934* [1]

Area	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Point Roberts	5	7	7	5	5	5	4	5	5	4	3	6	5	4	4	6	4	6
Boundary Bay (U. S. traps)	18	30	26	35	35	30	21	29	23	23	21	29	20	21	19	31	21	24
Birch Bay [2]	5	12	14	15	16	15	8	10	9	8	6	14	9	10	8	13	9	16
Lummi Island [3]	----	1	1	3	3	3	2	5	6	4	1	8	5	5	5	10	5	9
Rosario Strait [4]	1	5	1	1	2	2	1	2	2	2	1	3	1	3	4	5	5	12
South Lopez	----	----	----	----	----	----	----	----	----	----	----	----	----	2	----	----	3	4
Salmon Bank	----	5	6	6	7	5	4	4	4	4	3	5	5	4	4	4	4	5
Haro Strait	----	1	3	2	3	2	1	1	1	----	1	----	----	----	1	3	2	6
Waldron Island	----	----	----	1	1	1	----	1	----	----	----	1	----	1	----	1	----	2
West Beach	3	4	2	1	2	2	1	4	4	6	6	4	4	6	6	6	6	13
Ebeys Landing	----	----	----	----	----	----	----	----	1	----	----	----	1	1	----	1	1	----
Middle Point	----	----	----	----	----	----	----	----	----	----	----	----	1	2	1	1	2	4
Strait of Juan de Fuca [5]	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2
Admiralty Bay and Bush Point	----	1	4	3	4	----	2	5	4	4	3	3	3	3	3	2	3	8
Oak Bay and Point No Point	----	----	1	1	1	----	----	1	1	2	1	----	1	1	1	----	1	3
Hood Canal	----	1	1	2	----	----	----	----	----	----	----	----	----	4	4	----	4	4
Useless Bay and Possession Sound	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Meadow Point and south	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	3
East of Whidbey Island	----	----	8	5	4	----	----	3	1	3	3	3	3	3	3	2	2	10
Total	32	70	74	80	83	65	44	70	61	60	49	76	58	70	63	85	72	132

Area	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934
Point Roberts	5	7	5	6	5	6	2	4	4	6	7	8	5	8	8	5	3	3	5
Boundary Bay (U. S. traps)	19	29	19	18	14	21	11	17	12	19	14	19	16	28	18	21	10	22	22
Birch Bay [2]	9	14	10	9	3	8	3	8	4	10	7	9	7	10	8	7	3	7	6
Lummi Island [3]	6	9	5	5	4	5	3	4	3	4	4	4	4	5	5	6	4	4	3
Rosario Strait [4]	7	13	8	5	6	7	1	2	5	9	5	3	4	10	6	7	1	5	8
South Lopez	2	5	4	6	3	5	4	4	5	4	4	4	3	5	3	3	3	3	4
Salmon Bank	5	7	6	8	3	6	3	8	5	7	5	8	6	9	8	5	3	5	8
Haro Strait	4	7	5	6	2	6	2	6	4	9	4	6	4	9	5	5	----	3	5
Waldron Island	----	2	1	1	1	1	----	----	----	----	----	1	----	1	1	1	1	1	1
West Beach	11	13	12	13	12	11	9	13	12	12	11	11	13	12	15	8	4	5	7
Ebeys Landing	1	2	2	2	1	----	1	1	1	2	1	----	3	2	2	2	1	1	1
Middle Point	2	2	2	3	1	1	2	3	1	2	2	2	2	2	3	2	----	1	1
Strait of Juan de Fuca [5]	2	1	1	2	1	1	1	1	1	1	2	2	2	2	1	1	1	----	1
Admiralty Bay and Bush Point	9	7	9	7	6	4	3	7	7	8	8	8	9	9	11	11	3	8	7
Oak Bay and Point No Point	3	4	4	3	3	2	3	3	3	3	3	2	2	3	3	2	----	1	----
Hood Canal	2	4	4	4	2	----	3	4	1	1	----	----	1	1	3	2	----	----	----
Useless Bay and Possession Sound	1	3	1	1	1	1	----	----	----	1	1	----	----	----	----	----	----	1	1
Meadow Point and south	2	1	1	2	2	1	1	1	3	5	2	2	2	4	3	2	3	3	2
East of Whidbey Island	7	8	7	9	8	8	11	10	----	14	11	11	5	9	8	8	8	9	10
Total	97	138	106	110	78	94	63	96	71	117	91	100	88	129	111	98	48	82	92

[1] Incomplete before 1915.
[2] Including Alden Bank.
[3] Including Bellingham Bay.
[4] Including Padilla Bay and Guemes Island.
[5] South side.

During the period from 1915–34, 33 percent of all the traps have been located north of Sandy Point—Point Roberts, Boundary Bay and Birch Bay areas; 27 percent south of Sandy Point and north of Deception Pass—Rosario Strait, Salmon Banks,

[3] These trap locations have been determined from charts made by the U. S. Army Engineer's Office in Seattle, 1919–34, from the files of the State of Washington Department of Fisheries, and from numerous records and maps obtained from various operators. This table is not complete for years before 1915, and a few minor traps have not been identified as to location since that date. Since table 7 is based only on traps for which locality data are available, the numbers of traps do not check with table 6 giving the total number operated.

Haro Strait, Lummi Island, etc.; 16 percent along West Beach, Ebeys Landing, and the south side of the Strait of Juan de Fuca; 9 percent east of Whidbey Island—chiefly Hope Island area; and 15 percent south of Point Wilson—Admiralty Bay, Hood Canal, etc.

CANNERY EXPANSION FROM THE TRAP FISHERY

After more than a decade of cannery operation in the southern portion of Puget Sound, 1877–90, during which time 3 or 4 small canneries were annually engaged in the industry, business had fallen off to such an extent that only 1 cannery operated in 1890.

The successful use of salmon traps at Point Roberts resulted in the building of a salmon cannery at Semiahmoo in 1891, one at Point Roberts in 1893, and another at Friday Harbor in 1894, the number quickly increasing to 19 by 1900. In 1901, a big sockeye year, the number dropped to 16, owing to overproduction the previous year, especially of the cheaper grades. In 1902, however, the number rose again to 20 (see table 1). In 1902, in addition to the original sockeye cannery at Semiahmoo, there were 2 at Point Roberts, 3 at Blaine, 3 at Fairhaven (now South Bellingham), 1 at Chuckanut, 1 on Lummi Island, 6 at Anacortes, and 1 each at Friday Harbor, Port Angeles and Seattle. The successful use of salmon traps near Sooke, on Vancouver Island (see fig. 2) caused the building of a cannery at Victoria in 1905.

SEASON

One very striking instance of the increased intensity of fishing in later years is furnished by changes in the season when the fish traps were operated. The season has been measured by the dates of the first and last lift of a trap. Since the traps usually fish from about two days to as much as a week before the first lift, all seasons mentioned are slightly less than the actual time fished. In Boundary Bay, the most important sockeye area, the date by which half the traps had been lifted for the first time was July 9 in the period 1897–1902, in the next 8 years, it advanced to July 7, in the following 16 years it averaged July 4, and in the last period, 1927–34, it had advanced to June 25, a total for the whole period of 14 days. (See fig. 10.)

The change at the end of the season is more striking. From August 23 the closing date became later and later until, in the last 8-year period, it was September 27. A 46-day season had changed to one of 95 days. The reasons for the change are best explained by comparing trap seasons with the curves for seasonal occurrence of each species. It is evident that the late spring fishing is to increase the catch of kings. In the early days the traps usually stopped fishing in the odd-numbered years before the sockeye run was quite over in order to avoid bothering with the tremendous pink runs which were of little value. In recent years the traps have usually fished until the pink runs are over.

A somewhat similar story is told of the traps in the area between Point Wilson and Point No Point (Admiralty Inlet). Admiralty Inlet was a fall fishing area for many years. The opening date for the period 1900–1910 averaged August 27, and for the next 8 years August 23. From 1919–26 it had advanced to June 14 and in the last 8-year period, 1927–34 it was May 30, a change in the opening date of 85 days.

During the earlier years this southern area was fished chiefly for cohos and chums and the pink run was usually in full swing before fishing commenced. Later the fishing was advanced to take in all of the pink run, and more recently a large proportion of the traps made their first lift about May 4; evidently fishing immediately after the cessation of the April closed season to catch the early run of king salmon.

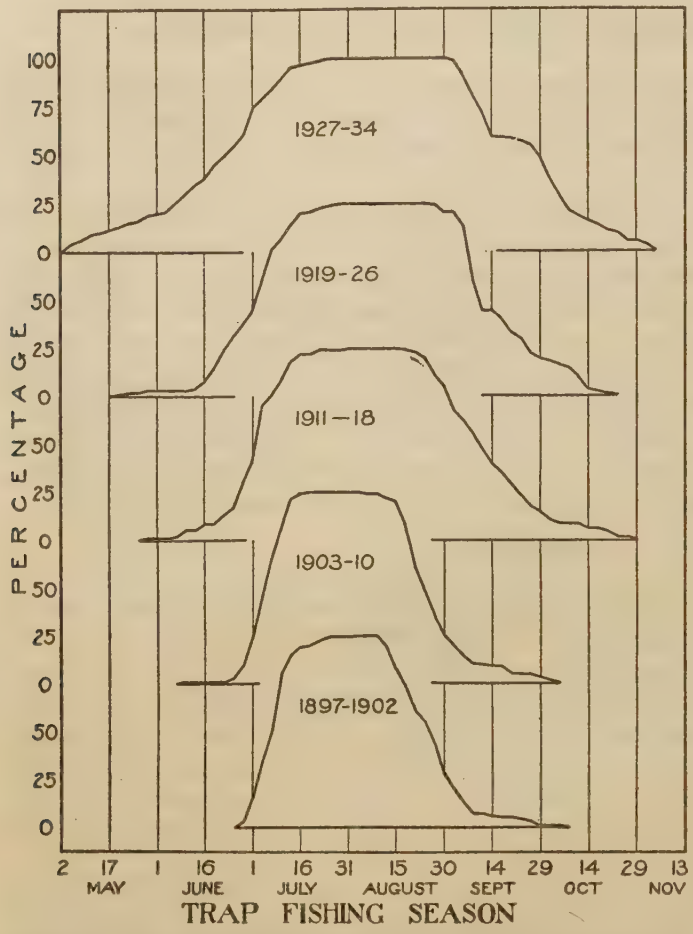


FIGURE 10.—Length of the trap-fishing season in Boundary Bay by groups of years from 1897–1934. The length of the season is gaged by the percentage of the traps that were actually in operation during the various parts of the season. Note the progressive increase in the length of the season during which they fished.

In the areas east of Whidbey Island the season was always very long. The traps opened in late April and early May to take kings and steel heads, and to be in time to fish the June run of sockeye to the Skagit River. They then remained open for the coho run in the fall.

The season fished by the traps has been modified somewhat by regulation. The first of these was a law, enacted in 1905, imposing a weekly closed season of 36 hours. Our data do not indicate any observance of this law prior to 1908. This weekly closed season was modified in 1915 to apply only during July and August. Commencing in 1921 it was applied during the balance of the year to the districts east of Whidbey Island and south of a line from Point Wilson to Partridge Point.

A closed season was introduced in 1915 from January 18–April 15, inclusive. This affected some forms of gear but had almost no effect on trap fishing. In Hood Canal an additional closed season from November 16 to January 1, inclusive, probably had some effect on the few traps in that area. The area near Tacoma, including Poverty Bay, was also closed from November 16–30, inclusive. The closed periods from 1921–34 are given in the following table.

TABLE 8.—*Puget Sound closed seasons from 1921–34* [1]

Year	All districts		Southern district [2]		Middle district		Northern district [3]			
	From—	To—	From—	To—	From—	To—	From—	To—	From—	To—
1921	Oct. 26	Apr. 30	Sept. 6	Sept. 15	Sept. 6	Sept. 15	Sept. 6	Sept. 15		
1922	Nov. 6	do								
1923	do	do	Sept. 6	Sept. 15	Sept. 6	Sept. 15	Sept. 6	Sept. 15		
1924	do	do	Aug. 25	Sept. 3						
1925	do	do	do	do	Sept. 6	Sept. 15	Sept. 6	Sept. 15		
1926	do	do								
1927	do	do	Aug. 25	Sept. 3	Sept. 6	Sept. 15	Sept. 6	Sept. 15		
1928	do	do								
1929	do	do	Aug. 25	Sept. 3	Sept. 6	Sept. 15	Sept. 6	Sept. 15		
1930	do	do			do	do	do	do	Sept. 21	Sept. 30
1931	Nov. 11	do	Aug. 25	Sept. 3	do	do	do	do		
1932	do	do	do	do	do	do	do	do		
1933	do	do	do	do	Sept. 11	Sept. 20	Sept. 11	Sept. 30		
1934	do	do	do	do	Sept. 2	Sept. 11	Sept. 2	Oct. 1		

[1] All dates are closed days.
[2] East of Whidbey Island and south of line Point Wilson to Point Partridge.
[3] North of line Sand Point to Patos Island (Birch Bay, Boundary Bay and Point Roberts areas).

The closed periods were introduced largely for the protection of the pink salmon and so at first were confined to the odd-numbered years, except in 1924, when it was hoped that there might be a fair run of pinks from the fry liberated by the hatcheries from eggs taken in Alaska. Since 1930 this closed period has been extended to the even-numbered years for the protection of the sockeye. The fall closing date was inaugurated in 1921 and applied to all districts. This closing protects a considerable portion of the chum salmon runs, and a small percentage of the cohoes.

SEASONAL OCCURRENCE OF EACH SPECIES

The seasons during which each species migrates through the salt water toward the spawning grounds is of the utmost importance from a standpoint of conservation as it determines, to a great extent, the possibilities of so regulating the fishery as to allow the taking of the more abundant species, while protecting the less abundant. There is, of course, considerable variation from season to season in the time of run, although a general average may be obtained. The traps furnish the best measure of seasonal occurrence since a trap does not fluctuate from day to day in its fishing effort, but continuously samples the runs that are passing by.

For sockeyes data were used for 12 traps, all located north of Deception Pass. They fished in various years from 1896–1934, catching a total of 13,129,869 sockeyes. In making a seasonal curve (fig. 11), the total catch of each 7-day period was divided by the number of trap-fishing days. However, for sockeyes the trap-fishing days for each trap were weighted by the fishing efficiency of that trap. (Cf. page 768.) For species other than sockeye the traps were not weighted.

For king salmon the catches of 17 traps were employed; 7 were north of Deception Pass, 4 at West Beach, 2 at Middle Point, 2 in the Hope Island Area, and 2 in Admiralty Inlet. They caught a total of 580,698 fish from 1900–1934.

The pink-salmon curve was derived from 4,467,115 fish caught in 16 traps; 9 located north of Deception Pass, 1 at Ebeys Landing and 6 in Admiralty Inlet. Since little effort was made to take pinks during the earlier years of the fishery, the material used is from odd-numbered years from 1919–33. As 1919 is the only year in

which a fall closed season was not in effect it was necessary to determine a small portion of the curve by empirical methods. The curves for the 9 northern and the 7 southern traps were each calculated separately and combined with equal weighting to obtain the final curve. (See fig. 11.)

To obtain the seasonal occurrence for coho salmon 26 traps were used; 15 located north of Deception Pass, 2 in the Hope Island Area, 2 in Middle Point Area, 1 at Dungeness Spit, and 6 in Admiralty Inlet. They fished from 1900–1934, taking 5,652,592 fish.

For the chum salmon, as for the pinks, a northern and a southern curve were each calculated and then combined. However, in the case of the chums, the southern curve was given double weight, as more chums are always caught in the southern areas. A total of 13 traps were used; 7 north of Deception Pass and 6 in Admiralty Inlet, catching 946,094 fish. The curves for all species are given in table 9 and shown in fig. 11.

TABLE 9.—*Seasonal occurrence in Puget Sound traps*

Week ending—	Percentage occurrence					Cumulative percentage occurrence				
	Sockeye	King	Pink	Coho	Chum	Sockeye	King	Pink	Coho	Chum
Apr. 21		0.425					0.425			
Apr. 28		1.353					1.778			
May 5	0.391	2.259		0.018		0.391	4.037		0.018	
May 12	.351	3.212		.035	0.001	.742	7.249		.053	0.001
May 19	.328	3.649		.059	.001	1.070	10.898		.112	.002
May 26	.149	3.780	0.002	.054	.002	1.219	14.678	0.002	.165	.004
June 2	.061	4.166	.002	.084	.006	1.280	18.844	.004	.250	.010
June 9	.018	4.770	.005	.080	.011	1.298	23.614	.009	.330	.021
June 16	.015	5.145	.006	.103	.008	1.313	28.759	.015	.433	.029
June 23	.087	5.921	.007	.175	.007	1.400	34.680	.022	.608	.036
June 30	.468	6.330	.010	.174	.013	1.868	41.010	.032	.782	.049
July 7	2.206	7.292	.017	.351	.026	4.074	48.302	.049	1.133	.075
July 14	4.495	6.696	.027	.393	.032	8.569	54.998	.076	1.526	.107
July 21	8.408	6.252	.170	.466	.063	16.977	61.250	.246	1.992	.170
July 28	16.098	6.188	1.463	.532	.172	33.075	67.438	1.709	2.524	.342
Aug. 4	26.344	6.072	3.660	.709	.450	59.419	73.510	5.369	3.233	.792
Aug. 11	20.911	6.149	6.875	.962	.816	80.330	79.659	12.224	4.195	1.608
Aug. 18	11.224	5.565	10.117	1.413	1.234	91.554	85.224	22.361	5.608	2.842
Aug. 25	5.542	4.456	21.120	2.717	1.863	97.096	89.680	43.481	8.325	4.705
Sept. 1	1.530	3.406	23.837	3.911	1.835	98.626	93.086	67.318	12.236	6.540
Sept. 8	.493	2.875	19.591	6.953	1.977	99.119	95.961	86.909	19.189	8.517
Sept. 15	.071	2.074	8.660	10.795	2.298	99.190	98.035	95.569	29.984	10.815
Sept. 22	.121	1.105	3.452	12.652	3.246	99.311	99.140	99.021	42.636	14.061
Sept. 29	.132	.451	.830	12.129	7.376	99.443	99.591	99.851	54.765	21.437
Oct. 6	.048	.167	.107	12.628	9.244	99.491	99.758	99.958	67.393	30.681
Oct. 13	.018	.069	.041	11.978	11.803	99.509	99.827	99.999	79.371	42.484
Oct. 20	.036	.041	.004	8.357	12.656	99.545	99.868	100.003	87.728	55.140
Oct. 27	.096	.038	.003	5.313	13.643	99.641	99.906	100.006	93.041	68.783
Nov. 3	.099	.064		3.108	10.335	99.740	99.970		96.149	79.118
Nov. 10	.258	.030		1.628	7.131	99.998	100.000		97.777	86.249
Nov. 17				1.502	5.747				99.279	91.996
Nov. 24				.667	3.282				99.946	95.278
Dec. 1				.051	1.865				99.997	97.143
Dec. 8				.005	1.097				100.002	98.240
Dec. 15					.431					98.671
Dec. 22					.669					99.340
Dec. 29					.553					99.893
Jan. 5					.066					99.959
Jan. 12					.015					99.974
Jan. 19					.006					99.980

The seasonal occurrence of each species is quite distinct from any of the others and the modes of the five curves are about a month apart; kings, sockeyes, pinks, cohos and chums following in that order.

The king-salmon run covers a long period of time, but averages much earlier than those of the other species. Thus 40 percent of the run is over by June 30, whereas no other species has reached 2 percent of its run by that date.

The next species to appear in abundance is the sockeye, overlapping the latter portion of the king-salmon run. On the average, over a long period of years, the sockeye runs have been practically over by August 25. By that date only 5 percent of the chums, and less than 10 percent of the cohos, have passed the traps. However, over 40 percent of the pink salmon run is complete.

The pink salmon run lasts for such a short period that it is practically over before the cohos appear in abundance, 85 percent having passed by the time 20 percent of the cohos are taken.

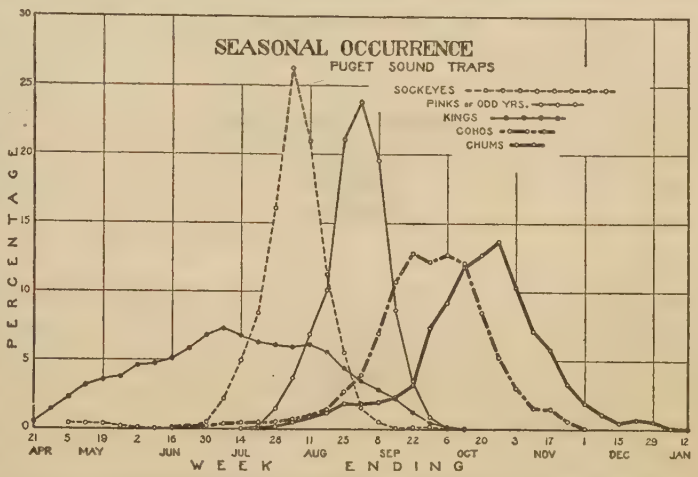


FIGURE 11.—Seasonal occurrence of all species of salmon as shown by Puget Sound trap catches. Each ordinate shows the percentage of the run occurring during the indicated 7-day period.

The coho and chum salmon are the backbone of the fall fishery. Neither species presents a well-defined mode, but the centers of the two distributions are between three weeks and a month apart. Since both species run for a considerable length of time there is a considerable degree of overlapping in their time of run. During the five 7-day periods, from September 23–October 27, inclusive, 54.7 percent of the chum and 50.6 percent of the coho runs occur.

RELATIVE IMPORTANCE OF EACH SPECIES AND DISTRICT

The relative importance of each species of salmon to the trap fishery is shown in figure 12 which illustrates the number of each species of salmon caught by traps in the 5 major areas during the past four decades. The areas shown are (1) North of Sandy Point, (2) Sandy Point to Deception Pass, (3) West Beach and Ebeys Landing, (4) the Strait of Juan de Fuca, and (5) the waters east of Whidbey Island and south of Point Wilson. For the past two decades the Puget Sound data are complete. Before that they represent only that portion of the trap catches for which original records could be secured. For sockeye this portion was about 80 percent of the trap catches in Puget Sound and practically all of the Canadian trap catches. For the other species the proportion represented is even higher than is the case for the sockeyes, as the data are more complete in the latter part of the period when more of the other species were used. For Canadian traps the other species are not included, as the data were not available.

From figure 12 it is to be noted that 53 percent of the entire catch came from the district north of Bellingham—Point Roberts, Boundary Bay, and Birch Bay Areas. The next largest district, from the standpoint of catch, was that south of Bellingham

(Sandy Point) and north of Deception Pass, which includes the San Juan Islands. The second district accounted for an additional 27 percent. In other words, 80 percent of the trap catches during the past 40 years have been from the areas north of Deception Pass. Of the remaining 20 percent, less than 11 percent came from the inside waters of Puget Sound—east of Whidbey Island and south of Point Wilson.

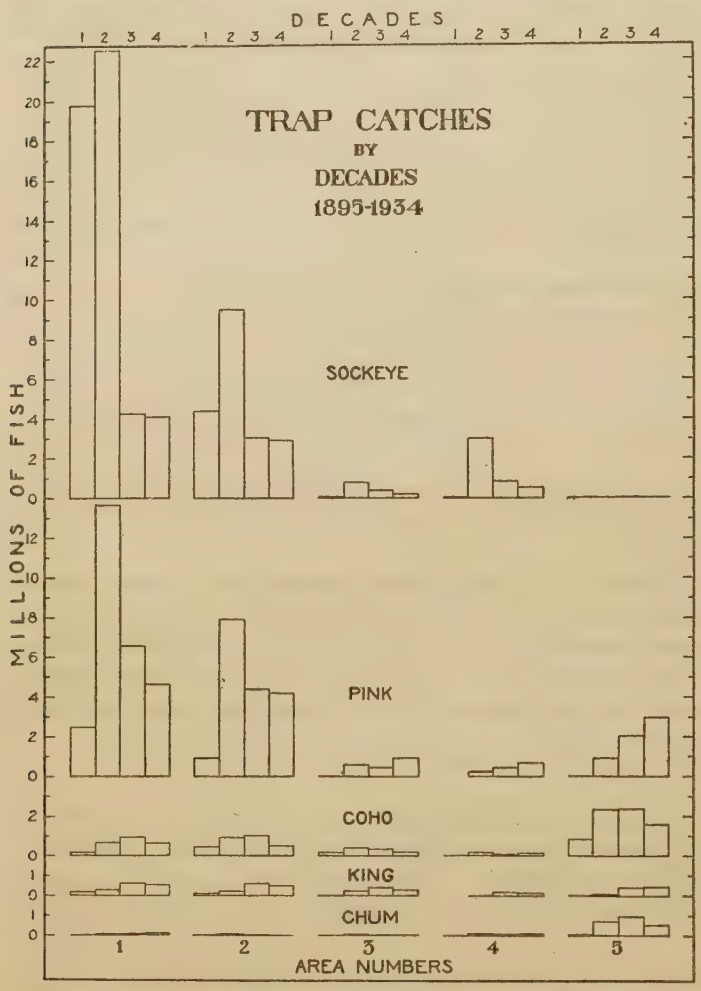


FIGURE 12.—Showing the number of each species of salmon caught by traps in the major areas during each of the past four decades.

Fifty percent of the trap catch were sockeyes, 34.9 percent pinks, 9.3 percent cohos, 3.6 percent kings, and only 2.2 percent chums. These figures, however, give only a general picture. If the catches are considered by districts it is found that the two districts north of Deception Pass caught 56.8 percent of the sockeyes, 36 percent of the pinks, 4.3 percent of the cohos, 2.6 percent of the kings, and 0.4 percent of the chums. That is, all but 7.3 percent of the catch consisted of but two species, sockeye and pink.

In the West Beach and Ebeys Landing district the catch was 32.2 percent pinks, 25.7 percent sockeyes, 20.8 percent cohos, 16.9 percent kings, and 4.4 percent chums; the sockeye and pink, the two dominating species north of Deception Pass, thus accounting for but 58 percent of the catch.

East of Whidbey Island and south of Point Wilson, except for the pinks, the catches are very different, being 43.5 percent cohos, 35.9 percent pinks, 13.9 percent chums, 6 percent kings, and only 0.8 percent sockeyes.

The changes in the catch by decades in each of the 5 districts are apparent. The catches of pinks, for example, after being subjected to exploitation in the second decade, 1905–14, fell off tremendously in the third and fourth decades in the two northern areas. In district 5, however, they have continued to rise.

THE PURSE-SEINE FISHERY

By George B. Kelez

The importance of the purse seines has varied considerably during the history of the salmon fisheries. Shortly after their introduction they surpassed the drag seine, their forerunner, and were in turn superseded by the traps. They again became an important factor when motor-driven vessels were employed. Since the use of traps has recently been prohibited in Puget Sound waters they are the only important gear operating in that district, and a knowledge of their effectiveness, the species taken, and the seasonal nature of operations in various areas, is of extreme importance to the administration of the fishery.

DRAG SEINES

One of the earliest forms of fishing gear to be used on Puget Sound was the drag seine. This was a long shallow net provided with cork floats on the upper edge and lead weights on the bottom, and was pulled by lines attached to each end.

In use the net was loaded into a skiff and one of the hauling lines passed to a man on shore. The skiff was pulled directly away from the beach until all the line was payed out, then turned parallel to shore and the net run out, after which the skiff returned to the beach with the second line. The lines were rapidly hauled in until the wings of the net were ashore and the fish concentrated in the center or "bunt" of the net, whereupon the remaining web was quickly hauled onto the beach, landing the catch. Since a beach free of large rocks or other obstructions was necessary for landing the catch, the drag seiners worked in unobstructed places where the fish were concentrated by favorable currents, or where their migration routes led them close inshore. The mouths of streams where the mature fish schooled before ascending to spawn were favorite locations prior to the passage of legislation protecting these areas.

The number of drag seine-licenses from 1897–1934 is shown in table 10. The greatest number of licenses was issued during the period from 1908–14, and that number steadily decreased thereafter.

Drag seines were commonly used in early years along the east shore of Vancouver Island and in Puget Sound near the cities of Seattle, Tacoma, and Olympia. They later appeared on the sands at the mouth of the Skagit River, the Nooksack River, and Lummi Slough, as well as at Point Roberts. They were also used extensively in the inlets and passages of the west shore of Puget Sound and in Hood Canal.

In early years the catch of this gear consisted chiefly of coho and pink salmon. Later, chum salmon became of considerable importance, and in some years large numbers of king salmon were caught. Subsequent to 1924 the total catch of the drag seines has been only a few thousand fish per year, consisting chiefly of pink salmon. Sockeye, which were caught only occasionally in former years, are now second in importance. These changes in the proportion of various species in the catch have been due in part to the competition of other forms of gear, but have re-

sulted chiefly from the closure, by legislation, of many districts which were frequented by the drag seines. This gear is still used in the region, but it is now of very little importance.

TABLE 10.—*Puget Sound drag seine licenses, 1897–1934*

Year	Number	Year	Number	Year	Number
1897	59	1911	307	1923	111
1898	59	1912	243	1924	109
1899	125	1913	238	1925	144
1900	114	1914	354	1926	130
1901	74	1915	187	1927	135
1902	74	1916	189	1928	120
1903	171	1917	218	1929	123
1904	95	1918	185	1930	123
1905	69	1919	187	1931	104
1906	123	1920	144	1932	84
1907	176	1921	116	1933	109
1908	283	1922	108	1934	90
1909	242				
1910	247				

DEVELOPMENT OF THE PURSE SEINE

EARLY SEINES

The purse seine is a net not unlike the drag seine in shape, but much longer and deeper. Its chief characteristic is the purse line, a stout rope or cable, rove through metal rings attached to its lower edge. This net is used in deep water. When a school of fish have been observed the net is set around them, the two ends are brought together, and the purse line hauled in. This closes the bottom of the net, trapping the fish within it. Although the purse seine is inseparably associated at the present time with the highly specialized vessel from which it is fished, the seine itself has undergone but little change, except in size, whereas the vessel is the product of long years of development and experience.

The date this gear was originally introduced on Puget Sound is a matter of conjecture. Hittell (1882) reported it to be an important form of gear in 1882. He stated that the fishery was prosecuted almost entirely by Indians and that the nets were from 50–80 fathoms in length, and 4–8 fathoms in depth. These seines were set from large canoes from which they were also pursed when the set was complete. Other canoes cruised around the net, the crews beating the water with their paddles to keep the fish schooled. Coho, pink, chum, and king are listed as the species caught, and from two to five thousand fish might be taken at a single haul. Hittell offers no information as to the date of introduction or as to the number of years that these nets had been used.

SCOW SEINES

This type of fishing must have undergone a considerable development in a brief space of time. Collins (1892) reports purse seines to be "the most effective form of apparatus yet used in the salmon fishery," and states that they were introduced in 1886. They are described as being approximately 200 fathoms long and 25 fathoms deep. They were set from a four-oared skiff, the after 8-foot portion of which was decked to form a platform for stowing the seine. A scow 20 feet long and 8 feet wide, equipped with a hand winch, was used for pursing the net and carrying the

catch. One end of the net was attached to the scow and the bulk of the seine was carried by the skiff, from which it was set around the school of fish. The free end was brought back to the scow where the two ends of the purse line were then hauled in by the means of the winch. A "plunger," consisting of a stout pole with a wooden box shaped like a truncated pyramid and attached to the lower end, was thrust repeatedly into the water at the opening between the purse lines to keep the fish from escaping there. This was necessary, since pursing the net was a very slow procedure. As high as 6,690 fish were taken in a single haul. At this time the principal fisheries on the Sound were at Seattle, which then had three canneries, at Tacoma, and at Port Townsend (see figs. 2 and 3).

Rathbun (1899) describes the purse seines in use about 1895 as essentially similar to those of 1888. He also dates their introduction to these waters as 1886, doubtless based on Collins' report, and gives their size as ranging from 150–250 fathoms in length, from 14–25 fathoms in depth, and being of 2½–3-inch mesh.

Rathbun states that in 1893 and 1894 several seines fished regularly at Point Roberts, some were employed at Port Angeles, and some in the San Juan Islands. The principal purse-seine fishery remained at Seattle, however, where the catches were sold to the fresh-fish markets as well as to the canneries. Eleven seines fished out of Seattle in 1895, and at least 20 in 1896. Individual hauls of from 1,500 to 2,500 fish were not uncommon, and one Seattle cannery received from 6 seines an average of 12,000 cohos a day during the height of the 1895 run. Although traps had become the chief source of salmon in other districts by 1895, the seines still supplied the greater part of all fish used in the Seattle area.

Purse-seine fishing in the San Juan Islands received considerable impetus from the location of a cannery at Friday Harbor in 1894, and three at Anacortes in 1896. Large shore camps, established at points close to the best fishing grounds, provided living quarters for the crews. The seine scows and skiffs were towed to these camps at the beginning of the run and remained there during the season. The individual seine outfits also had to be towed to various parts of the fishing grounds, for their own movements were limited to the distance that the boat-pullers could row the heavy skiff and attendant scow, and at the close of the day's fishing the whole apparatus had to be returned to the camp ground. Because of these limitations, fishing by purse seines was confined to a radius of a few miles from the base camps.

The first purse seines had been employed during the fall season in the southern districts of the Sound where the bulk of the catches consisted of coho salmon. Although large quantities of chum and pink salmon were available, the lack of a ready market curtailed the fishing for these species. A considerable increase in the number of canneries after 1895 furnished a better market for species other than coho, and the fishing season of the seines was considerably lengthened. The license records of the Washington State Department of Fisheries show that, during 1897, 22 licenses were issued during the month of June, 11 during July, 1 in August, and 13 in September. In 1898 approximately 31 licenses were issued up to and including July 6, and none thereafter until September 10. Nine licenses were issued after the latter date. It will be noted that the larger number of licenses were issued during the early summer, that few or none were issued during a slack period of several weeks, and that an addi-

tional number were issued in the later summer or fall. For convenience, the first group of licenses will hereafter be designated as "summer licenses," and the second group as "fall licenses" (see table 11). Although somewhat obscured by a general increase, the odd-numbered years show a larger number of licenses than do the even-numbered years. This is largely due to the greater availability in those years of the pink salmon, which by this time could be marketed in sufficient quantity to encourage their pursuit by the seine fleet.

TABLE 11.—*Puget Sound purse-seine licenses, 1897–1915*

Year	Summer	Fall	Total	Year	Total
1897	34	13	47	1907	64
1898	31	9	40	1908	69
1899	58	14	72	1909	95
1900	41	16	57	1910	120
1901	45	22	67	1911	133
1902	59	19	78	1912	169
1903	79	8	87	1913	252
1904	53	19	72	1914	288
1905	73	18	91	1915	308
1906	73	5	78		

DEVELOPMENT OF THE MODERN PURSE-SEINE VESSEL

Introduction of Power

Perhaps the most important single factor which influenced the development of the purse-seine fishery was the introduction of the internal-combustion engine for fishing vessels. The Pacific Fisherman Yearbook for 1919 states that the first gasoline-powered boat on Puget Sound, exclusively engaged in the fishing industry, was a 32-foot fish carrier, the Silverside, built in Tacoma about 1898 for T. E. Eggers, a pioneer operator of that city. In a few years the success of power in other fishing vessels encouraged the purse seiners to take advantage of this new development.

The complete change of the purse-seine fleet from oars to power was accomplished n a very few years. The Pacific Fisherman Annual Review for 1910 states:

> Skansie Brothers of Gig Harbor, pioneers in the use of gas engines, have ordered two new boats. They started six years ago (1904) with one boat powered with a 7 hp. "Frisco Standard". They have since bought 15 more.

The same publication, in the issue of 1907, includes in the caption of a picture of a power seiner the statement:

> **Gasoline power is now universally used in seine boats.**

From these statements we may conclude that the change to power in the seine fleet was completed in but little more than 3 years.

This change to power necessitated a revision of purse-seine fishing methods. The scow was replaced with a small open power boat and, although the skiff was retained, its function was reversed. The seine was now carried in the after part of the power boat. In setting, one end was made fast to the skiff while the seine boat circled the school of fish and payed out the net. The end of the net which had been made fast to the skiff was now brought aboard the seine boat and the purse line

FIGURE 13.—An early Puget Sound purse-seine vessel, of 12 net tons, built in 1909. Note the large house on deck containing the crew's quarters, and the outside steering wheel in front of the house.

FIGURE 14.—A gasoline-powered purse-seine vessel built in 1920, of 27 net tons. The ports forward indicate that the crew's quarters are in the forecastle. The "flying bridge" with steering wheel and controls, atop the wheel house, are visible. A seine skiff is towed astern.

hauled in by means of a winch. The time necessary to reach and surround a school of fish was thus greatly decreased, with a corresponding increase in the efficiency of the seine.

It has already been noted that purse seines became the most important type of gear in use on Puget Sound shortly after their introduction, and that by about 1895 the successful development of the salmon traps had relegated them to a position of much less importance. The adoption of power by the purse-seine fleet, which was consummated by 1907, now altered this position of minor influence in the fishery to one of considerable consequence, for what had been a relatively fixed type of gear became an extremely mobile one when the seine scows were superseded by power boats. This newly acquired mobility, allowing rapid shifting of operations during the season to any district in which salmon were abundant, has remained the outstanding characteristic of the purse-seine fishery.

Improvements in Vessel Design

The introduction of power was followed by a gradual but positive change in the type of vessels used. As the fishermen moved farther afield, the unsuitability of the open boat under adverse weather conditions soon became apparent, and seaworthiness became the major consideration when the seiners began fishing far out in the Strait of Juan de Fuca. The first improvement in design, a compromise hull partially decked forward, appeared shortly after power was introduced. Later vessels were built with a full deck, and, at the same time, their depth was increased considerably, providing greater carrying capacity and increasing their seaworthiness. By 1912 most vessels were full-decked. This roving type of fishery was greatly impeded by the necessity of the crew sleeping ashore, and crew's quarters were soon placed on board. At first a long superstructure was built, but the quarters were later arranged in a forecastle under a slightly raised forward deck. The wheel house and galley were brought forward partially over the raised deck, which afforded more deck space and increased the seaworthiness of the vessel.

The speed and maneuverability of the vessels was increased considerably as engine efficiency improved. These developments, together with the use of larger seines, brought about the introduction of the "turntable" upon which the seine was stowed. This was a free-turning platform mounted above the gunwales of the vessel at the stern, and still retaining the roller at the after edge, which had been used for many years. The seine could be payed out freely and rapidly from this turntable and also stowed thereon with far greater ease than before. At about the same time engine power was further utilized to operate the pursing winch. This reduced the labor and increased the speed of pursing the nets, thus effecting an increase in their efficiency.

Figure 13, which was taken before 1913, shows that the outside wheel had been adopted by that date. The fishing captain was thus enabled to steer the vessel while standing on the forward deck where he was better able to observe the fish and set the net. Some 10 years later this outer wheel was moved to the top of the wheel house, allowing still greater range of observation (see fig. 14). At about the same time a power drive was applied to the turntable roller, allowing the net to be gotten on board for stowing far more rapidly and easily than before.

Although the first Diesel-powered vessel on Puget Sound, the cannery tender *Warrior*, which was built in 1914 at Seattle by Nilson and Kelez (Pacific Fisherman Yearbook for 1919), was successful in operation and very economical, the original cost of these engines was too great to encourage their ready acceptance. However, during the years of expansion of the fleet following 1925, the many advantages of Diesel engines encouraged their installation in a majority of the new vessels. In recent years there have been no further radical changes in type or design of purse-seine vessels.

Increase in Vessel Size

Improvements in vessel design were accompanied by a parallel increase in vessel size. It is impossible to determine the exact size of all vessels in the fleets of early years, since most of them were of less than 5 net tons and were not required to be officially registered. We may obtain some indication of the increase in vessel size, however, from records of the vessels large enough to be registered. The average size of vessels of this class, built in 1906, was only 6 net tons. That of 1907 was 7.5 net tons, that of 1908 was 8.92 net tons, that of 1909 was 9.43 net tons, and that of 1910 was 9.97 net tons.

This tendency to build larger vessels received great impetus with the beginning of the high-seas fishery at Cape Flattery and on Swiftsure Bank, where there were frequent storms, few harbors, and no protection. Practically no seiners had fished there prior to 1911, but the development of this fishery was very rapid. Several vessels were laid down during 1911 of more than 10 net tons, and in 1912 nearly 50 vessels of 15–25 net tons were constructed. The size of vessels has continued to increase since that time.

EVALUATION OF FISHING INTENSITY

SEASONAL FLUCTUATIONS IN FLEET SIZE

Factors Affecting Seasonal Intensity

Variations in number of licenses in odd- and even-numbered years, and the licensing of an additional amount of gear in the fall of the year, have been noted in the discussion of scow seines. The operation of these factors was intensified by the conversion of the purse-seine fleet to power vessels and by the increase in vessel size which followed.

The larger seine vessels were now able to run from their home ports on Puget Sound to southeastern Alaska with little difficulty, and some even voyaged as far as Bristol Bay. The termination of the fishing season in Alaska usually occurred early enough to allow them to return to Puget Sound and fish during the coho and chum runs in the fall.

Since about 1925 the development of Alaskan herring-reduction plants attracted a fleet of large, able seine boats which fished from June to August or September, and many of which then returned to the Sound to further swell the fall fleet. Other large seiners, which fished in the California sardine fleets during the winter months, often fished in this region later in the year. During seasons when heavy runs of salmon were anticipated, certain vessels from the halibut fleet, which were constructed with a low stern suitable for seining, also engaged in the purse-seine fishery.

In even-numbered years, when the pink salmon did not appear, the departure of the larger vessels to other fisheries was especially common, and when the decreasing abundance of sockeye rendered summer fishing even less profitable many smaller vessels followed suit.

Other factors have further intensified the annual change in the number of vessels. Prior to 1921, when regulations in waters of the State of Washington were undertaken by the State Fisheries Board, a considerable fishery for immature coho salmon was carried on in lower Puget Sound, especially off the southern end of Whidbey Island, in Possession Sound, and in Port Susan (see fig. 3). This fishery was pursued by a number of very small boats which fished during April and May of each year. When the regular seining season began, in June or July, most of these small boats transferred their licenses to larger vessels and engaged in gill netting during the remainder of the season. Closure to early fishing of a large part of these waters discouraged seining by the smaller boats.

These various factors have caused considerable fluctuations in the size of the Puget Sound seine fleets, but have not obscured the striking difference in the number of seiners operating in the summer fleets of alternate years, or the distinct difference between the total fleets of odd and even years.

Size of Summer and Fall Fleets on Puget Sound

During the period from 1909–15, the number of seine licenses issued increased from 95 to 308 (see table 11). However, the dates on which fishing licenses were issued are available for only a few of those years, and the number of vessels fishing during different parts of the seasons cannot be determined for this early period.

Beginning with 1916, the vessels fishing on Puget Sound in each year have been classified as summer or fall seiners; all those obtaining early licenses were tabulated as the summer fleet, and all vessels fishing after September 6 as the fall fleet. In most years there was a period of from one to four weeks preceding this date during which no licenses were obtained. A more detailed discussion of the time of change from summer to fall fishing will be presented later under a discussion of the fishing seasons of the fleets. The number of vessels in the summer fleets of each year from 1916–34 are presented as column totals in the bottom line of table 12; those of the fall fleet of each year are similarly presented in table 13.

Table 12.—*Summer purse-seine fleets on Puget Sound, 1916–34*

Registered net tonnage [1]	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934
Below 5	4	30	23	21	25	2	1	----	----	2	----	----	----	3	1	1	1	1	1
5–9	32	40	11	14	5	7	2	5	3	5	3	3	3	6	5	7	3	5	5
10–14	78	103	37	46	16	45	12	24	9	27	13	22	9	26	13	22	17	23	22
15–19	81	121	52	56	36	69	15	30	13	41	19	43	34	46	35	55	42	56	54
20–24	44	82	43	53	30	51	13	24	6	21	13	22	20	39	35	45	41	42	43
25–29	3	25	16	18	31	47	8	22	11	24	12	26	21	41	37	48	42	46	41
30–34	1	23	9	20	10	21	6	14	8	11	5	19	17	24	21	40	33	32	34
35–39	----	1	1	3	1	1	1	2	1	1	1	2	1	6	2	20	15	16	14
40–44	----	----	----	----	----	----	----	----	----	1	----	----	----	2	2	5	4	6	4
45–49	----	----	----	----	----	----	----	----	----	----	----	1	----	1	3	4	1	2	1
Total	243	425	192	231	154	243	58	121	51	133	66	138	106	194	154	247	199	229	219

[1] Vessels of 5 net tons and larger from official registers; boats below 5 net tons from State license applications.

TABLE 13.—*Fall purse-seine fleets on Puget Sound, 1916–34*

Registered net tonnage [1]	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934
Below 5	6	31	24	23	26	3	1	1	1	3	----	1	2	4	4	1	1	4	1
5–9	36	40	11	15	7	7	3	4	3	6	4	3	3	6	5	8	4	5	5
10–14	90	106	45	54	23	46	27	26	20	29	20	26	22	26	18	22	18	25	22
15–19	88	125	58	63	43	69	36	35	26	47	36	44	44	49	47	56	45	56	57
20–24	51	83	50	58	34	53	27	28	16	27	19	27	25	39	38	45	42	44	43
25–29	4	26	19	19	33	49	22	23	16	29	28	33	34	41	40	48	42	47	43
30–34	1	23	15	20	13	22	12	14	9	14	20	32	31	27	30	40	34	34	36
35–39	----	1	1	3	1	1	2	2	2	2	2	8	6	10	8	20	15	17	15
40–44	----	----	----	----	----	----	----	----	----	1	1	----	----	3	2	5	4	8	4
45–49	----	----	----	----	----	----	----	----	----	----	----	1	1	1	4	3	1	2	----
Total	276	435	223	255	180	250	130	133	93	158	130	175	168	211	196	248	206	242	226

[1] Vessels of 5 net tons and larger from official registers; boats below 5 net tons from State license applications.

The data given in tables 12 and 13 are presented in graphical form in the top section of figure 15. The dotted line represents the size of the unallocated fleets from 1909–15. The size of the summer fleets from 1916–34 is represented by the solid line, and that of the fall fleets of the same years by the broken line.

A general consideration of the number of licenses indicates a continuous increase in numbers from 1909–15, an extremely high point in 1917, very small numbers during the years of post-war depression, and a considerable increase thereafter. The year 1917 stands apart as the peak in number of vessels during the entire history of purse-seining in this region; 425 vessels fished during the summer season and 435 during the fall. Pink salmon were abundant, the appearance of a big run of sockeye was anticipated, and a war-created demand for food had caused the price of raw fish to increase enormously. As a result, 122 new vessels were built that year, and almost every vessel on the Sound large enough to carry a net, including tow boats and pleasure craft, was engaged in purse seining. Although the regular seiners enjoyed a successful season, the sockeye run did not reach expectations, nor was the fall fishing especially profitable. Newcomers to the fleet found that purse seining was a most arduous vocation and that successful fishing was largely dependent upon the ability and experience of the vessel captain. These factors, coupled with the fact that 1918 was an off year for the summer fishery, caused the fleet of that year to shrink to more normal proportions, even in the face of a continued demand for fish. Except for the alternate rise and fall in odd-numbered years, the fleets remained approximately constant in number from 1918 to 1921. The abundance of most species of salmon had diminished considerably and this, together with the financial depression of 1921, resulted in a marked decrease in the number of vessels fishing in 1922.

Only three more vessels fished in the fall fleet of 1923 than in that of the previous year. This was the first year since the period of early development that the odd year showed so small a rise in number. The year 1924, when only 51 vessels fished during the summer season and 93 in the fall, was the first since 1909 in which less than a hundred vessels were licensed on the sound. However, beginning in 1925, the fleets again began to increase steadily in number. Although expansion ceased during the depression years following 1929, there followed no such decline as appeared in the period from 1922–24. The fleets of the 1930's, were of approximately the same size as were those immediately following 1917.

Size of Cape Seine Fleet

The purse-seine fishery in the waters off Cape Flattery and in the vicinity of Swiftsure Bank, which has long been called the "cape" fishery in this region, experienced a development similar to that of Puget Sound. For years the cape fleet has consisted of the larger vessels of the Puget Sound fleet, which fished there before the salmon runs began in inside waters, together with a few large vessels which have proceeded to other fisheries when the season was over.

During the years immediately following its development, tremendous catches encouraged many seiners to engage in this fishery. Most of the catch, however, consisted of immature fish which spoiled quickly, and the refusal of the canneries to accept them reduced the size of the cape fleet. This situation was met temporarily by butchering the fish at Neah Bay, and by icing the catches. Somewhat later the canners employed a fleet of fast tenders or "buying-boats", to which the seiners transferred their catches, and which then returned immediately to the canneries. This not only enabled the seine boats to remain at sea for longer periods of time, but insured the delivery of the fish ashore soon after they were caught. This development again encouraged the increase of the fleet.

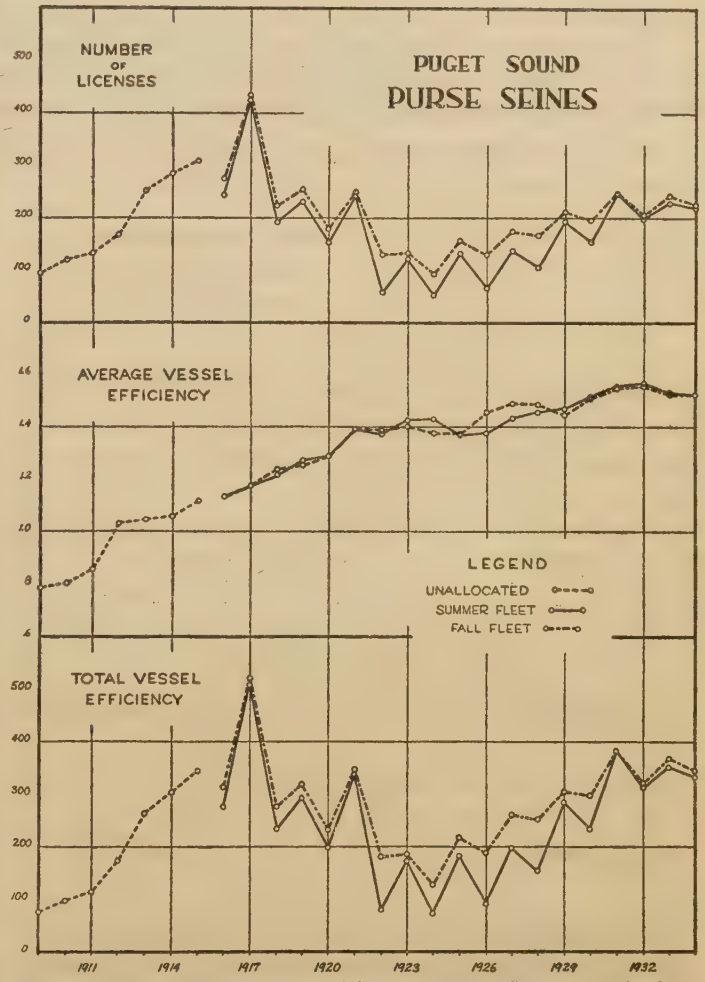


FIGURE 15.—Changes in numbers and efficiency of the Puget Sound purse-seine fleets. The early increase in size of the fleets, the decrease following the World War, and the increase during recent years may be seen, together with the general rise in efficiency throughout.

Since this fishery was conducted in waters outside the jurisdiction of the State of Washington, the vessels were not licensed and no record is available of the size of the annual fleets. Gilbert (1913) reported 22 vessels fishing at the cape in 1911, and more than 100 in 1912. Data furnished by the major part of the fishing companies in the region, which include the greater part of the landings from the cape, are quite complete

for the period from 1927–34. These figures indicate that the numbers of vessels fishing there during these years were 64, 88, 122, 75, 163, 117, 104, and 142, respectively.

CHANGES IN COMPOSITION OF THE FLEET

The size-composition of the annual purse-seine fleets was essential to a determination of fishing intensity, for vessel size is an important aid in the calculation of vessel efficiency.[4]

The changes in size that have taken place during the history of the purse-seine fishery are partially indicated in figure 16, which shows the size distribution of vessels fishing on Puget Sound during the years 1911, 1917, 1925, and 1933. Of the entire fleet fishing during 1911, there were only 6 vessels of 15 or more net tons. By 1917 vessels of this larger size constituted the major portion of the fleet, although a considerable number of smaller vessels were still fishing. A number of vessels of 24 or more net tons fished for the first time that year.

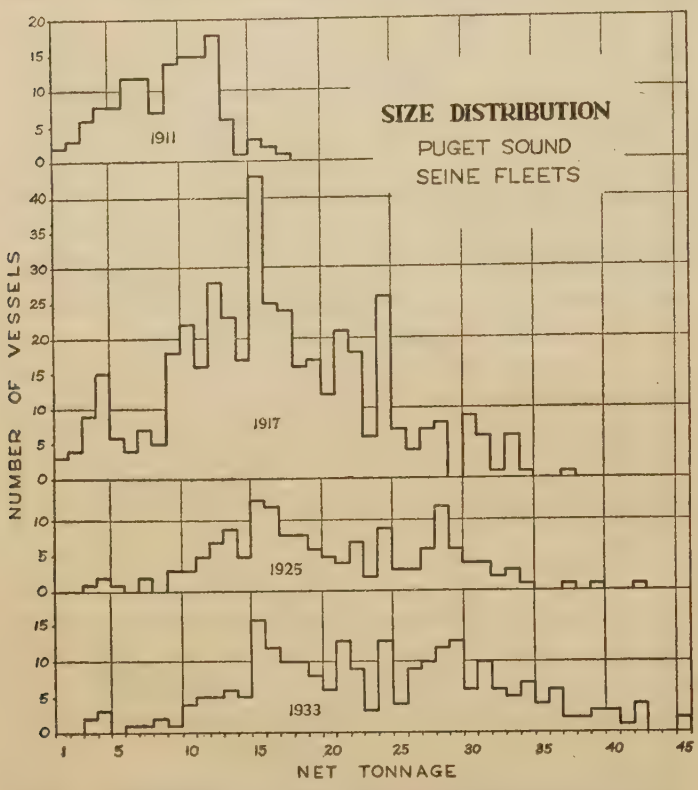


FIGURE 16.—Size distribution of vessels in the Puget Sound seine fleets at various intervals of development. The first histogram pictures the fleet shortly after the introduction of power; the second that of the exceptional year, 1917; the third the resumption of building after the post-war depression; and the fourth that of a recent year.

By 1925 vessels of less than 9 net tons had become scarce and the remaining fleet showed almost a bimodal size distribution, somewhat obscured by the presence of several vessels of 22 net tons built in 1915, and several of 24 net tons built in 1917; there is a mode at about 16 net tons, and another some 12 tons greater. Three vessels of more than 35 net tons fished in 1925.

In 1933 the small vessels had become even less numerous, and the remainder of the vessels, although similar in distribution to the fleet of 1925, show a considerable increase in the number of large vessels.

Because we are especially concerned with the fleets of the past 18 years, the year of building the vessels fishing during that time, and their size, are shown in table 14. The persistence of old vessels in the fleet is noteworthy, even though most of the smaller ones of early years have disappeared.

[4] In order to establish the size of vessels composing the fleets of various years, it was necessary to identify as many as possible of the individual vessels which had engaged in the purse-seine fishery of the region. By means of the license applications in the files of the Washington State Fisheries Department, the Fireman's Fund register of vessels documented on the Pacific coast, and the official Merchant Vessels Register of the United States Bureau of Navigation, the identity of 924 vessels was established, and the net tonnage, horsepower, and the year of building of each was recorded.

The increase in larger vessels in 1912, which resulted from the development of the cape fishery, is very apparent. These larger craft had been underpowered and not particularly successful, and smaller vessels were more popular during the next few years. The two large vessels, built in 1909 and 1911, were not built as purse seiners but were converted in later years.

The second abrupt size increase, beginning in 1916, was terminated by the depression in 1921. Building was resumed in 1924, but construction never reached the proportions of earlier years, for the declining abundance of salmon discouraged sustained building. It was at this time, however, that Diesel-engined vessels began to appear in the fleet. The depression following 1929 sharply curtailed the number of vessels under construction, and a recession in size similar to that in the years following 1921 is evident.

TABLE 14.—*Relation of size and year of building for vessels in the Puget Sound purse-seine fleet from 1915 to 1934* [1]

Net tonnage	Year built																	
	1895 to 1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
1							1	2	1			2						
2						1	2	1			2	1	1	2				
3						1			2	3	1		1	5	1	1		
4	1	1	1	1			1	1	2	2	2	1	1	1		2		
5		1			2		1	1		1	1			1	1			
6		3	1	1	1			1			1		1		3			
7	1	1		2			1	2	1	4		1				1		
8	1		2		2	1	1				3							
9	1	1		1	1	6	1			4		2	1		1	1		
10				1	1	6	6	2		7	2	1		1	1	1	1	1
11						1	10	2		3	2	2		2				
12		2	1		2	1	3	7	3	5	2	4	1			1		1
13	1			1	1	1	2	1	4	6	5	4		2		1		
14										10	4	1		1				
15								3	13	13	3	9	1	8	2			
16								1	5	4	6	8		4				
17									2	4	8	8	1	4				
18									4		4	5		6	1			
19									5	2	5	3		5			1	1
20									3		2	5		6				
21									3		5	8	2	5		1	1	
22									3		1	18		3		2		
23									4		1	2		2		1		
24									5	1		3		17	1	4		
25									1				1	5	1	1		
26						1								4	1		3	1
27													1	6		1	7	
28										1				10	1	3	10	
29								1								2	11	
30													1	8		1	2	
31														6	2	1	2	
32														1	1	2	2	
33													2	5	1	1		
34														1		2		
35																		
36															1	1		
37														1				
38																		
39																	1	
40																		
41																		
42																		
43																		
44																		
45																		
46																		
47																		
48																		
49																		
Total	5	9	5	7	10	19	29	25	61	70	60	88	15	122	19	31	41	4
Total tonnage	41	67	38	56	88	189	270	262	1,012	884	871	1,507	258	2,665	359	702	1,141	67
Average	8.20	7.44	7.60	8.00	8.80	9.95	9.31	10.48	16.59	12.63	14.52	17.13	17.20	21.84	18.89	22.65	27.83	16.75

[1] All vessels powered with gasoline engines prior to 1925, gasoline and Diesel ("oil") powered vessels listed separately thereafter.

TABLE 14.—*Relation of size and year of building for vessels in the Puget Sound purse-seine fleet from 1915 to 1934*—Continued

Net tonnage	Year built																		
	1924	1925		1926		1927		1928	1929		1930		1931		1932	1933	1934	
		Gas	Oil	Gas	Oil	Gas	Oil	Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas	Gas	Gas	Oil
1																		
2																		
3																		
4						1												
5																		
6																		
7																		
8																		
9																		
10											1					1		
11				1					1									
12									1									
13																		
14													1					
15		1							1									
16													1		1			
17																	1	
18	1																	
19	1					2	1			1		1						1
20		1																
21						2	1		1									
22									1	2								
23									1		1							1
24			1							1	1							
25														1				
26		1								1				3				
27			1				2		1	1								
28	1	1	1		1													
29		1		1	3		1		1									
30				1		1	2											
31					3	1	2		1									
32		1			1	2	1											
33			1		3	1				1								
34					3	2	3	1				1	1					
35							2	2				1						
36					1		6	1						1				
37							2			2								
38							1			3								
39										2								
40							1	1		1		1						
41																		
42			1							2		2						
43																		
44										1								
45												3						
46							1	1										
47																		
48								1										
49																		
Total	3	6	5	3	15	12	30	7	9	18	3	9	3	5	1	1	1	2
Total tonnage	65	150	154	70	477	276	854	256	188	564	55	347	62	139	15	9	16	40
Average	21.67	25.00	30.80	23.33	31.80	23.00	28.47	36.57	20.89	31.33	18.33	38.56	20.67	27.80	15.00	9.00	16.00	20.00
		27.64		30.39		26.90			27.85		33.50		25.13				18.67	

RELATION OF VESSEL SIZE TO EFFICIENCY

Any comparison of the number of vessels fishing in recent years to the number in any early year is of little significance unless consideration is given to the efficiency of the individual vessels of these respective periods. Many reasons may be offered for variation in vessel efficiency, but the greater number of these may be either directly or indirectly ascribed to the size of the vessel itself.

With the exception of two brief periods of unfavorable economic conditions, the size of the new vessels added to the fleet each year has been gradually increasing. The

newer vessels have been fitted out with better engines and equipment, and in recent years Diesel engines have been used almost exclusively by the larger vessels. These engines, allowing a far greater range of operation and greater economy than had been possible with gasoline engines, contributed much to the efficiency of the larger vessels.

The average horsepower of engines has also gradually increased. For example, the average power of vessels in the 10–14 net-ton class has increased from 22.4 hp. in 1915 to 30.9 hp. in 1934. Larger vessels show a lesser increase in the case of gasoline engines, but the many Diesel engines are of much greater power. The maximum power of the largest vessels prior to 1918 was 55 hp., whereas vessels above 45 net tons now average 132.5 hp. The present averages for the 7 size-classes of vessels between 10 and 40 net tons are 36.5, 46.0, 56.6, 68.1, 88.1, 97.0, and 109.8 hp., respectively. The relatively greater power of the larger vessels undoubtedly adds to their efficiency.

An important difference in earlier years existed in the size of the seine carried. In general, the larger seines were more efficient than the smaller ones and, since the size of the seine was necessarily limited by the space available for handling and stowing, it was generally proportional to the size of the vessel.

Throughout the years the human factor, although difficult of measurement, has always been of great importance. The most successful fishermen have constantly built larger and better vessels, while the older, smaller craft have usually been manned by less active men or by newcomers to the fishery. For these reasons the present analysis of vessel efficiency has been confined to a study of the relation of vessel size to size of catch.

In order to facilitate vessel-catch comparisons, the fleets of all years from 1916 to 1934 have been divided into size classes of 5 net tons each. The annual numbers of vessels in each class, for the summer and fall fleets, are given in tables 12 and 13.

Theoretically, any difference in efficiency between vessels of varying size should be reflected in a proportional difference in the average size of their catches. In order to determine such differences and to measure their degree, the average catches, over a considerable period of time, of vessels of different size classes were compared. Catch data used were from the years 1916–19, 1922–25, and 1928–34, in order to include the various building periods of the vessels and the fluctuations in fleet size. The size class of vessels from 10 to 14 net tons was selected as the unit of relationship since this class was well represented throughout the period of years covered.

Direct comparisons of annual average catches could not be used because of the seasonal fluctuations in abundance of the various species of salmon, with the resultant influence that the presence of one species might have on the size of the catch of another. Therefore, data for different species were used for comparison during different parts of the fishing season. Sockeye catches were used for determining averages for the summer fishery of even years, pink-salmon catches for that of odd years, and coho and chum catches for the fall fishery in all years.

Data for individual species were limited to the part of the season when they were sufficiently abundant to warrant fishing, and when other species were less numerous than the one sampled. Pink-salmon catches for most years were those from a period between July 29 and September 15. This period was shifted one week earlier in 1929 and one week later in 1933 in accordance with the time of appearance

of the runs. Catches of coho salmon used were those taken during a period between September 16 and October 27; this period was decreased by one week in both 1929 and 1930. The period used for chum salmon was from October 13 to November 6, except in years when the season was extended beyond the latter date. The periods for sockeye salmon were necessarily more varied than those for other species because of greater fluctuations in the time of run. Catches used were generally from the period between July 15 and August 15, although these dates were shifted when necessary, for example, to the period from July 29–September 8, in 1930, when the run was very late.

For each species the average delivery by vessels of each size class was determined by dividing the total number of fish caught, during the period selected, by the total number of deliveries made. No class was used in which less than 5 vessels fished with a minimum of 10 catches. For years in which the 6 size classes between 10 and 39 net tons were represented, the average catches of the individual classes were determined as percentages of the average catch of all classes. For early years, when data were available for only the smaller classes, the average catches were determined as percentages of the average catch of the total class range represented. In order to make the data for early years comparable with those for later ones, the percentages of the individual size classes were proportionately reduced so that their sum was equal to the average sum of the percentages of an equal class range in the years when all classes were represented. The sums of the percentages in all years were divided by the number of years to determine the average percentage for each class, and the ratio of these averages to that of the class from 10 to 14 net tons was calculated for each species.

These relative-efficiency ratios for each species, and for the average of all species, are presented in table 15. The sockeye salmon show the smallest and least consistent differences between vessel classes. Large catches of this species have frequently been made by vessels of all sizes fishing in certain limited areas on the Salmon Banks, near Lummi Island and at Point Roberts (fig. 2). Here peculiarities of winds and tides, or advantages of geographical location in relation to migration channels, have caused dense schooling for brief periods of time, and disproportional catches have been made by many vessels.

TABLE 15.—*Relative efficiency of Puget Sound purse-seine vessels* [1]

Species	Vessel size in five-ton classes [2]							
	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40 and larger
Sockeye [3]	0.66	1.00	0.99	1.46	1.56	1.43	1.55	1.59
Pink [4]	.92	1.00	1.27	1.64	1.85	2.02	2.33	2.25
Coho	.83	1.00	1.15	1.69	2.19	2.27	2.37	2.12
Chum	.79	1.00	1.21	1.43	1.70	1.78	1.91	1.98
All species	.80	1.00	1.16	1.56	1.82	1.88	2.08	1.99

[1] Proportion of the average annual catch of each species taken by each size class, calculated on basis of 10–14 class as unity.
[2] Size in net tons, official register.
[3] For even years only.
[4] For odd years only.

The ratios of the other species show a consistent increase with vessel size except in the group of vessels of 40 or more net tons. In this particular class, two species show increases and two decreases as compared with the next smaller class. The average ratios of all species were used as the final measure of relative vessel efficiency. The efficiency of boats of less than 5 net tons was arbitrarily set at 0.5, since sufficient data were not available from which a ratio for this class might be calculated.

The average vessel efficiencies of the Puget Sound fleets from 1909–34, based upon these ratios, are shown graphically in the center section of fig. 15. The abrupt increase in the efficiency of the 1912 fleet is due to the construction of large vessels in that year. Efficiencies of the summer and fall fleets are quite similar, with the exception of the period after 1923. The divergence shown here is due to considerable variations in the number of small boats fishing. .The general trend of the average efficiency is upward, with a slight decline in 1933 and 1934. It is evident that the fleets of recent years are, boat for boat, about twice as efficient as were those of 1909 and 1910.

The total efficiency figures for the fleets from 1909–34 are presented in table 16. The same data are shown graphically in the bottom section of fig. 15. The great increase in efficiency in early years, as well as the considerable rise during recent years, is obvious. Judging from the actual number of licenses issued, as shown in the top section of the figure, there were 7 years between 1913 and 1921 in which the number of vessels fishing was greater than the average number fishing between 1931 and 1934. However, it is apparent from the figures of total vessel efficiency that the average of the last 4 years has been exceeded only once, in 1917, and approached closely in only 2 other years, 1915 and 1921. It is thus evident that, with the exception of the abnormal year 1917, the intensity of the purse-seine fishery on Puget Sound has been potentially greater during recent years than at any previous time in the history of the fishery.

TABLE 16.—*Relative efficiencies of Puget Sound purse-seine fleets, 1909–34* [1]

Year	Summer fleet	Fall fleet	Unallocated	Year	Summer fleet	Fall fleet
1909			74.58	1922	79.70	180.54
1910			96.68	1923	172.84	186.32
1911	112.06	113.86		1924	72.98	128.22
1912			174.22	1925	181.75	217.19
1913			263.10	1926	91.04	189.31
1914			304.30	1927	197.79	260.91
1915			343.48	1928	154.30	250.07
1916	275.54	312.60		1929	284.69	304.62
1917	509.10	520.62		1930	233.63	295.58
1918	232.82	275.94		1931	384.17	384.14
1919	294.02	319.48		1932	312.21	320.93
1920	198.36	231.10		1933	351.06	369.32
1921	338.30	348.44		1934	333.83	344.80

[1] For years 1909, 1912, 1913, and 1914, actual sizes of all boats unknown; efficiencies calculated from proportionate sizes of identified boats, which were 84, 70, 42, and 45 percent of the respective fleets of those years.

SEASONAL OCCURRENCE OF EACH SPECIES

PUGET SOUND FISHERY

In certain areas several species of salmon may be present in considerable numbers at the same time, and during parts of the season a single purse-seine haul usually contains all five species. The seiners are able to make a certain amount of selection as to the species they wish to catch, however, by operating in different localities.

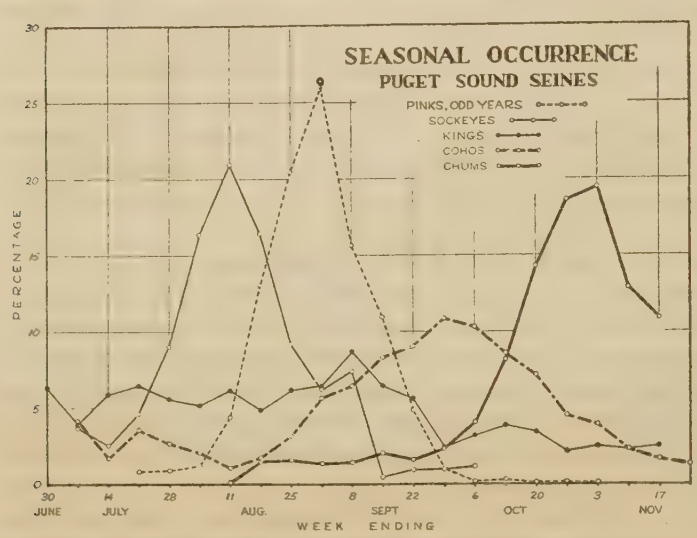


FIGURE 17.—Seasonal occurrence of the various species in the catch of Puget Sound purse seines.

In order to determine the seasonal progression of the various species in the fishery, the average daily delivery, by 7-day periods for each year from 1911–34, was calculated for each of them; data from all vessels of 10–39 net tons being used. The 7-day averages over the 24-year period were then calculated, and determined as percentages of their sum (see table 17 and fig. 17). The curves do not show the relative abundance between species, but indicate for each species the average proportion appearing in the catches of successive weeks during the fishing season. The pink-salmon curve represents occurrence only in odd-numbered years.

Although there is considerable overlapping in the time when the various species appear, a distinct progression throughout the season is apparent, and the peaks of the runs of all species, except king salmon, occur at intervals of 3–4 weeks. These curves correspond closely to those from the trap fishery. The more prolonged periods of abundance of the various species indicated by these data may be attributed to the ability of the seiners to move with the fish, making their catches in whatever region that affords the greatest abundance at any particular part of the season.

TABLE 17.—*Seasonal occurrence in Puget Sound purse seines*

Week ending—	Percentage occurrence					Cumulative percentage occurrence				
	Sockeye	King	Pink	Coho	Chum	Sockeye	King	Pink	Coho	Chum
June 30		6.314					6.314			
July 7	3.685	3.966		4.181		3.685	10.280		4.181	
July 14	2.534	5.864		1.709		6.219	16.144		5.890	
July 21	4.629	6.466	0.805	3.561		10.848	22.610	0.805	9.451	
July 28	9.070	5.542	.847	2.690		19.918	28.152	1.652	12.141	
Aug. 4	16.352	5.136	1.189	2.055		36.270	33.288	2.841	14.196	
Aug. 11	20.914	6.110	4.393	1.020	0.102	57.184	39.398	7.234	15.216	0.102
Aug. 18	16.481	4.847	13.066	1.738	1.437	73.665	44.245	20.300	16.954	1.539
Aug. 25	9.199	6.119	20.484	3.162	1.536	82.864	50.364	40.784	20.116	3.075
Sept. 1	6.142	6.398	26.069	5.602	1.297	89.006	56.762	66.853	25.718	4.372
Sept. 8	7.437	8.737	15.539	6.396	1.391	96.443	65.499	82.392	32.114	5.763
Sept. 15	.488	6.432	10.895	8.282	2.017	96.931	71.931	93.287	40.396	7.780
Sept. 22	.916	5.576	4.843	9.043	1.602	97.847	77.507	98.130	49.439	9.382
Sept. 29	.994	2.449	.999	10.834	2.324	98.841	79.956	99.129	60.273	11.706
Oct. 6	1.158	3.212	.204	10.286	4.076	99.999	83.168	99.333	70.559	15.782
Oct. 13		3.873	.291	8.564	8.138		87.041	99.624	79.123	23.920
Oct. 20		3.449	.128	7.147	14.272		90.490	99.752	86.270	38.192
Oct. 27		2.169	.142	4.522	18.593		92.659	99.894	90.792	56.785
Nov. 3		2.508	.106	3.948	19.487		95.167	100.000	94.740	76.272
Nov. 10		2.288		2.279	12.866		97.455		97.019	89.138
Nov. 17		2.542		1.672	10.860		99.997		98.691	99.998
Nov. 24				1.311					100.002	

CAPE FISHERY

The seasonal occurrence of the various species in the cape fishery has been determined in the same manner as that for Puget Sound. Adequate data, however, were not available prior to 1927. These data are presented in table 18.

The sockeye and pink-salmon runs at the cape reach their seasonal peaks at about the same time as in the inside fishery (see fig. 17), but the former species is more concentrated at the time of the peak of the run. The king salmon run is generally similar to that of the inside fishery. The coho season at the cape differs considerably from that on Puget Sound. Large numbers of fish are taken during the first part of the season and the early cessation of fishing obscures what undoubtedly would be a fall run similar to that in Puget Sound waters. Occurrence of chum salmon has not been calculated because they form only a very minor part of the cape catches.

TABLE 18.—*Seasonal occurrence in cape purse seines*

Week ending—	Percentage occurrence				Cumulative percentage occurrence			
	Sockeye	King	Pink	Coho	Sockeye	King	Pink	Coho
June 23	0.192	2.526		13.959	0.192	2.526		13.959
June 30	.635	7.629	0.805	7.319	.827	10.155	0.805	21.278
July 7	.947	6.134	1.206	8.831	1.774	16.289	2.011	30.109
July 14	.939	8.296	2.511	5.275	2.713	24.585	4.522	35.384
July 21	2.021	6.114	4.101	5.828	4.734	30.699	8.623	41.212
July 28	6.048	9.176	6.003	6.536	10.782	39.875	14.626	47.748
Aug. 4	12.496	7.528	6.540	5.531	23.278	47.403	21.166	53.279
Aug. 11	30.768	10.075	12.880	3.799	54.046	57.478	34.046	57.078
Aug. 18	30.368	12.096	9.886	3.526	84.414	69.574	43.932	60.604
Aug. 25	8.561	11.449	18.723	4.988	92.975	81.023	62.655	65.592
Sept. 1	3.151	10.570	22.554	4.905	96.126	91.593	85.209	70.497
Sept. 8	3.341	6.265	14.145	8.884	99.467	97.858	99.354	79.381
Sept. 15		2.142	.484	10.930		100.000	99.838	90.311
Sept. 22	.531		.163	3.038	99.998		100.001	93.349
Sept. 29				1.863				95.212
Oct. 6				4.788				100.000

FISHING SEASONS IN DIFFERENT DISTRICTS

PUGET SOUND

Purse seining on Puget Sound usually begins in the early summer in the region of the San Juan Islands, the greater number of vessels fishing on or near the Salmon Banks (see fig. 2). As the season progresses the vessels work farther inside to Rosario Strait, Lummi Island, and Point Roberts, and, especially in years when pink salmon are abundant, in Haro Strait. In even years there is a slack period between the summer and fall seasons in which little fishing is done. In the odd years the pink-salmon run extends to the late summer closed period (see table 8).

Fall fishing begins shortly after this slack period. In odd-numbered years some vessels may remain in the northern districts for the last of the pink-salmon run, but the remainder of the fleet will shift to the eastern part of the Strait of Juan de Fuca from Ediz Hook to Middle Point, and the southern shores of the San Juan Islands. A short time later most of the vessels will move to Admiralty Inlet. Much of the late fall fishing is in the inlets and passages of lower Puget Sound. In even years the fall fishery is similar, except that such vessels as fish during the slack period between the summer and fall fisheries usually operate in the lower part of the strait at an earlier date.

Seining is carried on by Canadian vessels along the eastern shore of Vancouver Island and in seining areas 17–20 (see fig. 2), except that the portion of area 17 which is adjacent to the mouth of the Fraser River has, until recent years, been open to fishing only during the time of the pink and chum runs.

The intensity of the seine fishery during different parts of the season is dependent largely upon the abundance of fish. However, the number of fish caught does not truly represent the effort expended by the fleet for fishing intensity may be very high, even though only moderate catches are made. The best measure of effort which may be determined from present records is the average number of deliveries made in a uniform period of time. During the greater part of the season buyers pick up fish at fairly regular intervals, and the number of deliveries made to them should closely approximate the intensity of the fishery.

The number of deliveries in each week of odd- and even-numbered years from 1916–34, except 1920 and 1930, were calculated as percentages of the total number of deliveries made in each year. The year 1930 was omitted because of unusual differences in the time when the run of certain species occurred, and because of the curtailment of fishing in certain areas by administrative orders; 1920 was omitted because of inadequate data. The average percentage of the season's deliveries, of the Puget Sound fleet, made in each week for both odd and even years were then determined, and are shown in the first two columns of table 19.

TABLE 19.—*Average proportion in each 7-day period of the total annual deliveries of the Puget Sound and cape seine fleets*

Week ending—	Puget Sound fleet, 1916 to 1934 [1]			Cape fleet, 1927 to 1934		
	Odd years	Even years	Even years weighted [2]	Odd years	Even years	Even years weighted [2]
June 9				0.032		
June 16				.021	0.051	0.041
June 23				.615	2.933	2.361
June 30	0.020	0.005	0.003	3.705	10.765	8.665
July 7	.324	.143	.091	5.934	9.858	7.935
July 14	.906	.728	.463	7.570	10.432	8.397
July 21	2.462	2.882	1.833	13.474	15.043	12.108
July 28	3.836	5.586	3.553	9.193	11.546	9.293
Aug. 4	4.841	5.945	3.781	16.971	10.795	8.689
Aug. 11	5.470	5.583	3.551	18.926	4.942	3.978
Aug. 18	6.768	4.873	3.099	11.812	9.011	7.253
Aug. 25	10.303	4.153	2.641	4.870	3.084	2.482
Sept. 1	10.461	2.402	1.528	4.616	2.189	1.762
Sept. 8	7.425	1.504	.957	.473	4.328	3.484
Sept. 15		2.431	1.546	.235	3.552	2.859
Sept. 22	4.324	3.926	2.497	.667	.664	.534
Sept. 29	4.771	5.956	3.788	.541	.247	.199
Oct. 6	5.753	7.708	4.902	.028	.180	.145
Oct. 13	6.767	8.846	5.626	.266	.088	.071
Oct. 20	7.367	10.401	6.615	.050	.138	.111
Oct. 27	7.432	11.095	7.056		.064	.052
Nov. 3	7.077	10.458	6.651		.076	.061
Nov. 10	3.178	4.449	2.829		.013	.010
Nov. 17	.416	.875	.556			
Nov. 24	.099	.050	.032			
Total	100.000	99.999	63.598	99.999	99.999	80.490

[1] 1920 and 1930 omitted.
[2] Percentages in even years weighted by ratio of average number of deliveries in even years to average number of deliveries in odd years.

The week ending September 15 has been omitted from the odd years, since in all years except 2, 1917 and 1919, a closed period has been enforced. The catches made during this week in these 2 years were not included when the percentages for these years were calculated. The last 3 days of the preceding week were also included in the closed period. The catches for this week have been estimated on the basis of the daily average for the 4 days of the week during which fishing was permitted, and the percentages calculated from the estimated figures. Because a similar closed period has been enforced in the last 2 even years, the percentages for the closed weeks during these years were estimated on the average of the same weeks of the remaining 6 even years in which this closure was not operative.

Because the fleets in odd years have been larger than those in even years it was necessary, in order to show the proportionate intensity of the fishery, to reduce the even-year percentages in the same proportion that the average number of even-year deliveries bore to the average number of odd-year deliveries. From these weighted figures, appearing in the third column of table 19 and shown in the lower section of figure 18, it is immediately apparent that the increased intensity in odd years is confined largely to the summer fishery, and that the relative size of the summer and fall fisheries is reversed in odd and even years.

In both odd and even years deliveries start shortly before July 1. In even years they increase rapidly to a peak during the last part of July and the early part of August, begin to decline about the middle of August, and by the first week in September have almost ceased. Shortly after this the fall fishery begins, with a gradual increase

each week until a peak is reached in the last week of October. From this point the fishery declines abruptly.

Fishing in odd years also increases during July, but, whereas the even years show a decline in August, the odd-year fishery continues to increase during that month to the highest point in the season. The slack season between summer and fall fishing follows, but is not so accentuated as in even years, even though the closed period terminates fishing entirely for a short time. After September 15 the fall fishing begins, increases to a peak about the middle of October, and then declines rapidly; the mode is more protracted than in even years.

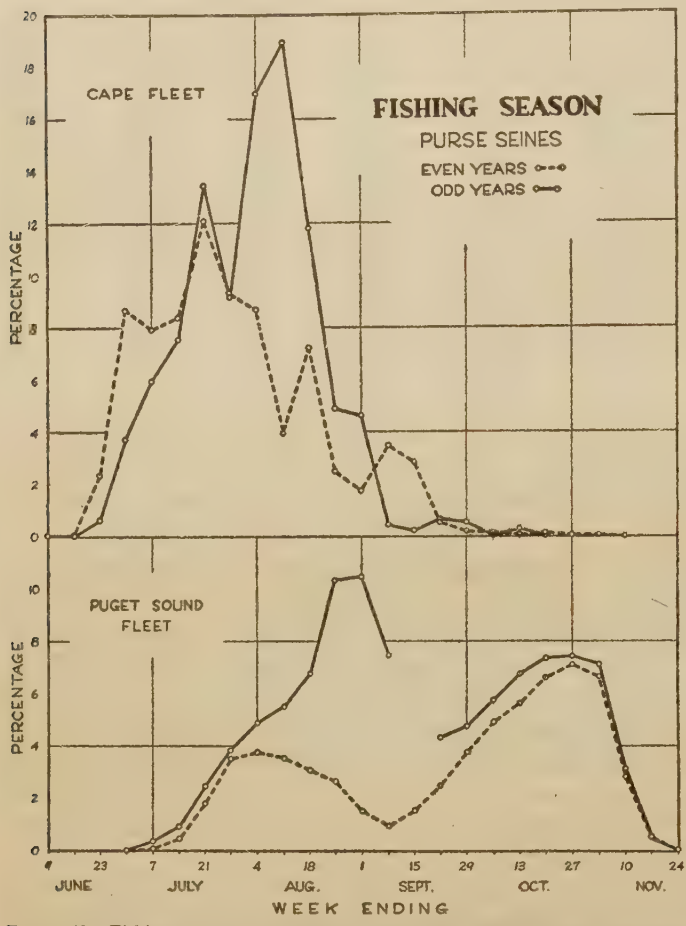


FIGURE 18.—Fishing seasons of the cape and Puget Sound fleets in odd and even years. The early season at the cape, the influence of the large runs of pink salmon in odd years in both districts, and the summer and fall fisheries on Puget Sound are indicated.

CAPE FLATTERY

This fishery is generally carried on during the early summer, after which most of the vessels move to the inside waters where better protection from adverse weather is afforded, and where there is a greater concentration of fall-running fish.

The average proportion of deliveries made during each week of the season was calculated for odd and even years in a manner similar to that for the Puget Sound fishery. These data are presented in the last three columns of table 18. The even-year percentages have again been weighted by the proportion of the average total numbers of even- and odd-year deliveries. These data are less smooth than those of the Puget Sound fishery because of the small number of years, 4 odd and 4 even, for which records are available.

The curves of proportional intensity in odd and even years are presented in the upper section of figure 18. It will be noted that in both cases fishing begins during the latter part of June and is generally concluded early in September. In even years more than 60 percent of the deliveries have been made before the first of August, the catches being largely taken from the coho populations feeding on the banks.

In the odd years a considerable number of catches are made throughout July, but the peak of the season is reached during the pink run in the month of August. Fishing terminates rather abruptly thereafter, the bulk of the vessels moving to the inside waters.

RELATION OF FISHING INTENSITY TO SEASONAL OCCURRENCE

Both seasonal occurrence and fishing intensity determine the proportion of the annual catch made at different intervals in the season. In order to portray the seasonal distribution of the catch, the percentage taken in each 7-day period was calculated, for vessels of 10–39 net tons, for each year from 1916–34. The years 1920 and 1930 were omitted for reasons previously explained. The average percentages, by 7-day periods, were calculated for both odd and even years.

These weekly percentages differ from the previously calculated figures for fishing intensity in that they show the relative number of fish caught during uniform parts of the season, whereas the intensity figures represent the fishing effort during similar periods.

Since it is also important to know the contribution of the individual species, their proportionate representation in the weekly catches of each year from 1916–34 were calculated and the average weekly proportions for odd and even years determined.

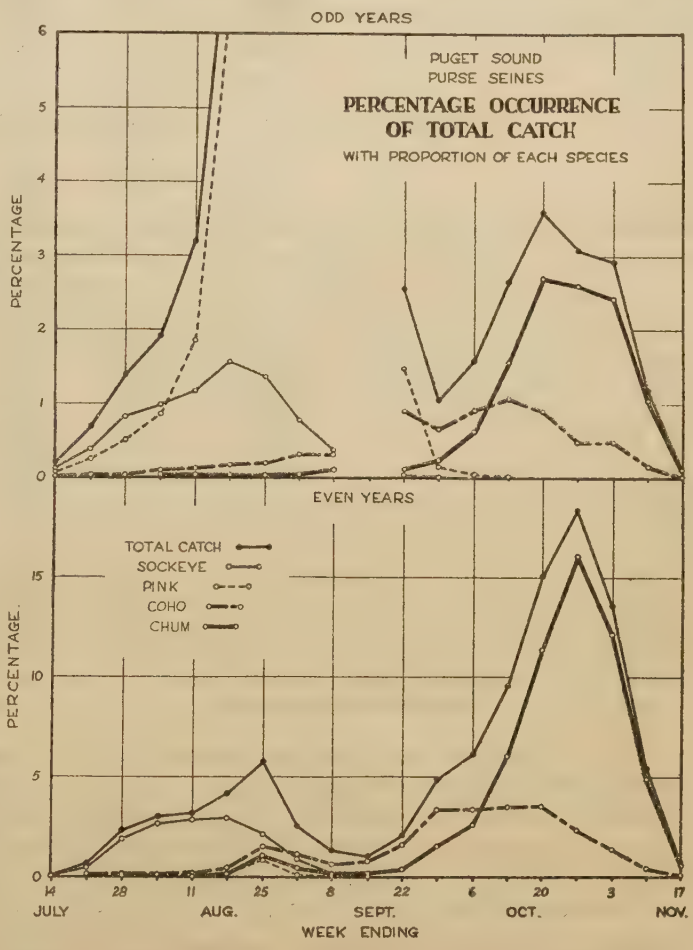


FIGURE 19.—Seasonal distribution of the catch of Puget Sound purse seines and the proportional contribution of the various species. The striking difference of the importance of the summer and fall fisheries in odd and even years is readily apparent.

Corrections were made for closed periods in a manner similar to that described in the calculation of seasonal fishing intensity. The average proportion of the catch taken by weeks, and the average representation of the individual species are presented, for both odd and even years, in table 20 and in figure 19.

TABLE 20.—*Average proportion of each species in the weekly catch of Puget Sound purse seines and percentage occurrence of total catch, 1916–34*

Week ending—	Odd years					Percentage total catch
	Sockeye	Pink	Coho	Chum	King	
July 7	71.766	19.500	7.018	0.577	1.140	0.091
July 14	56.546	34.241	5.767	1.761	1.685	.196
July 21	57.659	37.819	3.069	.250	1.203	.674
July 28	58.108	35.618	3.165	1.833	1.275	1.390
Aug. 4	59.657	44.138	4.082	.163	.960	1.918
Aug. 11	36.438	58.393	3.767	.450	.953	3.187
Aug. 18	19.450	77.595	2.132	.149	.675	8.007
Aug. 25	6.588	92.098	.965	.091	.258	20.568
Sept. 1	2.790	95.650	1.116	.119	.324	27.791
Sept. 8	2.013	95.096	1.769	.650	.472	17.446
Sept. 15 [1]						
Sept. 22	1.673	58.246	35.109	4.540	.432	2.548
Sept. 29	1.142	14.147	62.718	21.447	.546	1.034
Oct. 6	.371	2.811	57.527	39.046	.245	1.580
Oct. 13	.138	.882	39.625	59.077	.278	2.631
Oct. 20	.002	.076	24.294	75.298	.329	3.608
Oct. 27		.054	15.315	84.447	.184	3.081
Nov. 3	.006	1.179	16.236	82.408	.172	2.931
Nov. 10		.721	11.909	87.219	.151	1.191
Nov. 17			6.210	93.440	.349	.102
Nov. 24			11.584	88.331	.085	.026
	Even years [2]					
July 7	78.415	1.453	19.094		2.038	.011
July 14	77.125	1.734	15.074	.328	5.739	.057
July 21	75.982	1.863	16.738	.288	5.388	.682
July 28	85.061	3.669	6.949	.028	4.264	2.289
Aug. 4	86.776	5.072	4.746	.082	3.324	3.070
Aug. 11	87.745	3.527	4.426	.181	4.121	3.197
Aug. 18	71.489	3.964	11.527	4.215	8.805	4.174
Aug. 25	37.173	13.813	26.204	17.536	5.274	5.753
Sept. 1	31.253	2.252	42.864	18.214	5.416	2.566
Sept. 8	13.785	1.251	56.441	22.021	6.503	1.316
Sept. 15	.217	1.410	75.811	20.243	2.319	1.035
Sept. 22	.296	.392	78.907	18.978	1.428	2.081
Sept. 29	.397	.072	67.506	31.576	.449	4.920
Oct. 6	1.086	.155	55.412	43.137	.209	6.114
Oct. 13	.002	.015	36.479	63.319	.184	9.529
Oct. 20	.033	.035	23.647	76.066	.219	15.052
Oct. 27	.011	.028	12.412	87.235	.265	18.367
Nov. 3		.010	9.996	89.816	.178	13.625
Nov. 10		.012	7.475	91.544	.970	5.423
Nov. 17			12.802	87.149	.049	.680
Nov. 24			2.807	97.126	.067	.058

[1] Omitted because of closed period.

[2] 1920 and 1930 omitted.

The curves for even years are presented in the lower section of the figure, and those for odd years in the upper section. The curves for kings were omitted, since the highest point in any one week in even years was less than 0.4 percent, and in odd years was less than 0.1 percent. The scale for odd years was increased so that the proportion of the run afforded by all species other than pinks should be equal in odd- and even-numbered years. Because of the extreme peak the odd-year curve was truncated, hence the percentage occurrence of the total catch and the proportion represented by pink salmon are not shown for the weeks from August 18 to September 8. These curves vary most from those of fishing effort in the more extreme differences between the summer and fall fisheries. It is evident that the number of fish per delivery is much greater during the height of the run of pink salmon in odd years and during that of chum salmon in even years.

It is apparent that the late summer fishing for pink salmon in odd years in the northern districts of the sound has caused some extension of sockeye catches, and this is further demonstrated by the absence of chum salmon in the catches. In even years, although the summer fishery begins to decline much earlier, such vessels as are fishing are operating in districts where the early chum runs are found, and increased catches of chums appear more than a month earlier than in odd years.

The predominance of chum salmon in the fall fishery of even years indicates a greater effort to take this species when the lack of pink salmon has resulted in a poor season for the seiners. The peak of the fall fishery is reached during the week ending October 27. In odd years the peak of the total catch is reached a week earlier, shortly after the coho run has reached its maximum, and the curve begins to decline while chums are still abundant.

RELATIVE IMPORTANCE OF EACH SPECIES

PUGET SOUND

The sum of the Puget Sound purse-seine catches from 1917–34 was 64,978,888 salmon, of which 37,559,326 were pink salmon, 12,653,382 were chum salmon, 9,121,238 were sockeye, 5,383,438 were coho, and 261,504 were king salmon. Large and small runs of pink salmon appear in alternate years. In years of abundance, odd years, they have averaged over 4 million fish a year and have provided approximately 75 percent of the catch, in the even years they have averaged little more than 6,000 a year and have furnished less than 1 percent of the catch. Their average for all years is 37.44 percent (see table 21).

The average chum-salmon catch over 18 years has been approximately 700,000 fish per year. Seven of the 9 even-year totals are considerably above this figure, reflecting the more intense even-year fishery. During this period the average proportion of chums in the annual catches was 32.07 percent.

Although over 9 million sockeyes have been taken during this period, nearly 6 million were caught during only 3 years; almost 2 million in 1917, nearly 2½ million in 1930, and over 1¼ million in 1934. The remaining 15 years averaged approximately 226,000 fish. The annual average for sockeyes was 15.63 percent over the 18-year period.

The catches of coho salmon show smaller fluctuations than do those of the above species; their average has been approximately 300,000 fish per year during this period. They averaged 14.16 percent of the annual catches.

King salmon are a negligible factor in the purse-seine catches, averaging less than 15,000 fish per year. This species has provided an average of only 0.7 percent of the total catches during the 18-year period.

TABLE 21.—*Proportion of various species in total annual catches of Puget Sound purse seines, 1917–34*

Year	Sockeye	King	Pink	Coho	Chum	Total catch [1]
1917	14.31	0.29	62.99	3.71	18.70	11,804,026
1918	2.35	2.13	.26	32.35	62.91	1,376,757
1919	4.10	.93	47.25	10.64	37.08	4,349,421
1920	3.05	.66	.03	22.82	73.44	775,421
1921	5.06	.39	78.18	11.86	4.51	3,079,015
1922	9.88	.79	.43	45.51	43.39	875,233
1923	4.39	.12	82.10	4.80	8.59	4,042,288
1924	10.35	.52	1.11	17.91	70.10	1,127,020
1925	3.32	.21	83.85	5.38	7.25	5,656,515
1926	13.69	.47	.36	28.33	57.15	1,168,848
1927	11.12	.43	78.64	5.04	4.76	4,549,007
1928	6.65	2.08	1.53	27.06	62.68	1,164,682
1929	6.79	.21	72.72	4.19	16.09	6,359,144
1930	81.24	.61	.80	4.25	13.10	3,567,442
1931	5.28	.39	81.44	4.23	8.66	5,468,739
1932	24.43	1.32	.36	17.40	56.49	1,716,772
1933	9.93	.34	81.64	2.77	5.32	5,531,318
1934	65.43	.61	.30	6.61	27.05	2,367,240
Average	15.63	.70	37.44	14.16	32.07	

[1] Total catch of all species in numbers of fish.

Although approximately 58 percent of the total number of fish caught during this period have been pink salmon, they have been abundant only in odd-numbered years. In the alternate years chums have provided approximately half the catch, with cohos and sockeye next in importance.

CAPE FLATTERY

The contributions of various species to the purse-seine catch at the cape differ considerably from those on Puget Sound. Records are not available for the numbers of seine-caught fish taken at the cape before the period from 1927–34, during which 14,166,769 salmon were caught. Of these, 10,395,194 were pink salmon, 2,305,290 were cohoes, 1,348,553 were sockeye, 69,433 were kings, and 48,299 were chums.

Pink salmon have averaged 84.56 percent of the catch in odd years and 8.53 percent in even years. Their average for all years is 46.54 percent. During the period for which accurate figures are available, more than 73 percent of the total number of fish landed at the cape have been pink salmon (see table 22).

TABLE 22.—*Proportion of each species in the total annual catches of Cape Flattery purse seines, 1927–34*

Year	Sockeye	Pink	Coho	Chum	King	Total catch [1]
1927	2.10	89.66	7.92	0.03	0.29	2,382,838
1928	6.81	23.73	67.48	.57	1.40	290,222
1929	2.60	85.96	11.01	.07	.35	3,924,375
1930	23.49	6.85	66.33	1.89	1.43	614,170
1931	4.97	89.37	5.16	.17	.32	4,367,412
1932	5.44	1.66	87.60	3.38	1.92	359,900
1933	10.50	73.25	15.15	.71	.40	1,153,429
1934	62.80	1.87	34.01	.35	.98	1,074,423
Average	14.84	46.54	36.83	.90	.89	

[1] Total catch of all species in number of fish.

Coho salmon are next in importance, furnishing the greater part of the early-season catch in all years. During the even years they averaged 63.86 percent of the catch, and during the odd years, 9.81 percent. Their all-year average is 36.83 percent.

The sockeyes show the same heavy catches in 1930 and 1934 noted in the Puget Sound fishery, providing 23.49 percent and 62.80 percent of the catch, respectively. Their average for the even years is 24.64 percent, for the odd years 5.04 percent, and over the 8-year period 14.84 percent.

King salmon, although taken throughout the season, provide only a very small proportion of the cape landings. The catch figures are somewhat reduced, however, by the practice of buying small kings as pink salmon, and occasionally as cohoes. The average in the even years is 1.43 percent, in odd years 0.34 percent, and over the 8-year period was 0.89 percent.

Chum salmon are caught infrequently in the offshore waters. Their average is 1.55 percent in even years, 0.25 percent in odd years, and was 0.90 percent over the 8-year period.

THE TROLL FISHERY

By George B. Kelez

Fishing with hook and line was engaged in by natives of the region long before commercial salmon fishing began, but this gear never became of significance until the introduction of power boats. As was true of the purse seine, little change has taken place in the gear itself, whereas a considerable improvement has been made in the boats from which it is fished. Although individuals of all five species of salmon are landed occasionally, only the coho and king salmon are readily taken by trolling.

The early Indian gear consisted of lines twisted from bark or animal sinews, a stone weight, and a hook of bone or of wood with a bone point. Although "spoons" (lures) of shell were in use, the principal Indian fishery was with baited hooks, herring being chiefly used for this purpose. According to Rathbun (1899) the fishing season at Neah Bay was during the months of June, July, and August.

Another interesting but little-known type of native gear, which developed from the trolling line, is shown in fig. 20. It consists essentially of a bladder float to which is attached a line of twisted sinew suspending a stone weight. A second line is fastened to the weight, and the free end is attached to a shank of whalebone bearing a double hook of bone lashed with bark. As many as thirty of these units were attached together, each hook was baited with a whole herring, and the string was drifted from a canoe. Both types of gear were fished close to the surface, and the principal catch was coho salmon, preferred by the natives because of its suitability for drying.

DEVELOPMENT OF THE FISHERY

For many years commercial trolling was of little importance. Collins (1892) did not include it among the commercial fishing methods listed for the region, but stated:

> The Indians employ trolling hooks and spears in the Sound and small streams tributary thereto, and parties fishing for pleasure also use spoon hooks and trolling lines. Also, the Indians at Neah Bay use trolling lines, and in 1888 took 7,000 pounds of salmon valued at $140. A much larger catch could, no doubt, be made at this place. . . .

Rathbun (1899) included trolling gear among commercial methods, but stated that its use was restricted both as to locality and number of men employed, and that

it was still chiefly fished by Indians. The principal catch was king and coho salmon. Kings were fished from November to February, and sometimes to April, in the Gulf of Georgia, both in the region of Nanaimo and off the mouth of the Fraser River (see fig. 2). They were also taken in the vicinity of Victoria, in the San Juan Islands, off Port Townsend, in the upper part of Admiralty Inlet, and in Hood Canal. Cohos were taken in smaller numbers, although good catches were made in Boundary Bay and in the waters of lower Puget Sound. Rathbun also stated that the catch of trolling gear was much less than that of the gill nets in the region. Fishing was conducted from canoes or skiffs, and by one or not more than two men to a boat. Spoons and hooks baited with herring were in general use.

The introduction of power, which had almost as great an effect on trolling as it did on fishing with purse seines, eliminated the rowing or paddling of the skiff or canoe, and thus greatly reduced the labor of fishing. The fishermen were now able to cover greater distances, were less subject to the force of the tides, and could attend to more lines. Larger, more able boats soon came into use, and the fishing area was extended over the entire inner waters of the region, while the size of the catch of the boats was increased remarkably.

By 1908 the trollers were fishing well out into the Strait of Juan de Fuca, and by 1911 they were operating on the open ocean in the vicinity of Cape Flattery. With the development of the offshore fishery, still larger boats appeared in the trolling fleet. These carried a small cabin which housed the engine and provided cramped quarters for the crew when at anchor.

Although the greater part of the trolling boats remained at some base, such as Neah Bay, and fished during the early hours of the day, the larger boats, which were of 30–35 feet in length, made trips of 2 or 3 days duration. These were designated as "overnight" boats, in contrast to the majority, which were "day" boats.

The gear fished by these boats now consisted of as many as six lines, often carrying from two to three spoons and hooks each. The lines were suspended from poles of varying lengths hung outboard over the sides of the boat, one pair usually at the bow and one amidships. Metal spoons were almost universally used, but herring bait was still favored by a few single-liners. The power gurdy, which was introduced in 1918, was a multiple reel, driven off the motor, by means of which the lines could be hauled in whenever a fish was hooked. This greatly increased the speed of handling the lines. Figure 21 illustrates the mounting of this device, together with the lead-in blocks by means of which the lines are brought from the poles to the gurdy reels. The fish hatch is forward of the gurdy, and the cockpit, from which the boat is steered and the lines handled while fishing, is immediately aft of it. With the exception of the adoption of the Diesel engine, giving greater cruising radius and more economical operation, there has been little further change to the present time.

IMPORTANCE

It is difficult to obtain accurate records as to the number of trollers operating in the region during most of the past years. Some of these boats fished entirely on the high seas and were not licensed by the State of Washington, while others roved from Monterey Bay in California to Southeastern Alaska, fishing for varying periods along the coast according to the abundance of the fish.

FIGURE 20.—Modified floating hook-and-line gear used for coho salmon by the natives at Neah Bay before white fishermen operated in that district. The bone hook was baited with a whole herring. From the collection of Captain T. E. Eggers.

FIGURE 21.—Stern view of trolling boat. Note the two hand-operated gurdies and the lead-in blocks directly over them and on both gunwales. The two main poles may be seen at the sides of the mast.

Records of licenses issued between 1917 and 1934 by the Department of Fisheries of the State of Washington for the Puget Sound district, which also embraces the territorial waters in the vicinity of Neah Bay, are presented in table 23. Boats fishing exclusively offshore did not have licenses prior to 1917 as none were issued. Gilbert (1913) reported 250 trollers in the cape region in 1911 and stated that this was an "unprecedented number." He estimated more than 400 there the following season. Smith and Kincaid (1920) reported more than 500 boats fishing at the cape in 1918.

We may assume that the fishery was of little importance prior to about 1910, and that the number of boats increased thereafter to a maximum in 1919, the last 3 years of this period being included in table 25. There was a marked decrease in licenses during the period of economic depression following 1921, and again in the similar period after 1931.

TABLE 23.—*Puget Sound trolling licenses, 1917–34*

Year	Number	Year	Number	Year	Number
1917	782	1923	221	1929	656
1918	982	1924	374	1930	784
1919	1,032	1925	438	1931	599
1920	611	1926	684	1932	259
1921	415	1927	820	1933	220
1922	165	1928	672	1934	478

During recent years practically all the boats have fished in the region of the cape, some as far as Forty-mile (La Perouse) Bank. A few of those fishing in Puget Sound operate in the San Juan Islands, but most of them fish the waters south and east of Point Wilson. A large fleet of Canadian trollers operates off the west coast of Vancouver Island, and a small fleet fishes in the upper part of the Gulf of Georgia for coho salmon. Some boats work off the southeastern part of Vancouver Island for kings.

The catches of the cape and Puget Sound fleets for recent years may be found in the sections on coho and king salmon. For the 8-year period from 1927–34, Puget Sound trollers took 104,692 cohos and 18,285 kings. During the same period, the cape fleet took 2,411,312 cohos and 1,545,178 kings. In addition, a few thousand pink salmon are taken at the cape in years of abundance, and occasional catches of the other species are made.

SEASONAL OCCURRENCE OF COHOS AND KINGS

Species other than coho or king appear so infrequently in trollers' catches that their occurrence may be disregarded. In the early part of the season kings are taken almost exclusively, but after the first of May both species appear in most of the catches. Seasonal occurrence is not so well defined in the troll catches as in other gear, for landings at any station, such as Neah Bay, may contain fish caught at a considerable distance from the landing point. In the early season the trollers fish longer, more heavily weighted lines, thus increasing their chance of taking the deeper-swimming king salmon. In the latter part of the season they fish closer to the surface in order to take cohos. Many fishermen shift during the fall from the plain metal spoons used in early summer for kings to ones which have been painted red on one side and which

seem to be more efficacious for cohos. For these reasons the occurrence of the species in the troll catches do not reflect their relative runs as accurately as do those from less selective gear.

Catches were available for from 174–261 trolling vessels landing at Neah Bay during the years from 1922–28. Because of the extreme difficulty in identifying the boats, no attempt was made to treat their catches individually. For both kings and cohos the average daily delivery per boat during each week of the season was calculated for the individual years, and from these data the averages over the 7-year period were calculated. These were then determined as percentages throughout the season. The percentage occurrence of both species by weeks is presented in table 24.

TABLE 24.—*Seasonal occurrence in cape trolling gear*

Week ending—	Percentage occurrence		Cumulative percentage occurrence		Week ending—	Percentage occurrence		Cumulative percentage occurrence	
	King	Coho	King	Coho		King	Coho	King	Coho
Apr. 21	1.523	----------	1.523	----------	July 28	4.960	5.255	61.046	45.604
Apr. 28	3.600	----------	5.123	----------	Aug. 4	5.036	4.547	66.082	50.151
May 5	4.787	1.846	9.910	1.846	Aug. 11	4.494	5.212	70.576	55.363
May 12	3.320	.761	13.230	2.607	Aug. 18	4.846	6.585	75.422	61.948
May 19	2.905	2.867	16.135	5.474	Aug. 25	4.477	5.840	79.899	67.788
May 26	4.543	2.072	20.678	7.546	Sept. 1	2.932	4.608	82.831	72.396
June 2	6.519	3.139	27.197	10.685	Sept. 8	2.448	5.515	85.279	77.911
June 9	4.152	2.182	31.349	12.867	Sept. 15	4.304	6.227	89.583	84.138
June 16	3.669	3.186	35.018	16.053	Sept. 22	3.493	6.713	93.076	90.851
June 23	4.114	3.861	39.132	19.914	Sept. 29	3.882	3.427	96.958	94.278
June 30	3.347	4.717	42.479	24.631	Oct. 6	2.046	2.450	99.004	96.728
July 7	4.184	3.813	46.663	28.444	Oct. 13	.949	2.038	99.953	98.766
July 14	4.859	5.520	51.522	33.964	Oct. 20	.047	.740	100.000	99.506
July 21	4.564	6.385	56.086	40.349	Oct. 27	----------	.494	----------	100.000

There is a short period of heavy catches of king salmon in early May, followed by the main period of occurrence lasting from June to the latter part of August. There is a third small run in the latter part of September which decreases immediately after the first week in October. The coho catches build up slowly during a period of about two months prior to the middle of July, remain, with some fluctuations, at that level until the third week in September, and decrease thereafter to the last week in October.

A comparison of the cumulative percentage occurrence figures from trolling gear (see table 24) with those for cohos and kings in cape purse seines (see table 18) indicates some of the differences in these two fisheries. The first troll-caught kings are taken in the week of April 15–21, 25 percent of the catch is made by the end of May, 50 percent by July 14, 75 percent by August 18, and 100 percent by October 20. Seine-caught kings do not appear before the middle of June, 25 percent are taken by July 14, 50 percent by August 6, 75 percent by August 22, and 100 percent by September 15. The trollers will have been operating for about two months before the seiners begin, and slightly more than 50 percent of the troll catch has been made by the time that 25 percent of the seine fish are landed. The two curves cross during the latter part of August, and the seine season is over before 90 percent of the troll-caught fish are landed.

Trollers begin landing cohos about the first of May, 25 percent of the catch is taken by the first of July, 50 percent during the first week in August, 75 percent by the first week in September, and the season ends during the latter part of October. The seiners begin fishing cohos about the middle of June, and 25 percent of the catch is

made by July 4, 50 percent by August 3, 75 percent by September 4, and 100 percent by the first week in October.

It will be noted that the differences in time of the king catches are due mainly to the length of season fished, and that there is little similarity in the time of the 25th percentiles. In the case of cohos, however, the 25th, 50th, and 75th percentiles of both types of gear coincide. The heavy catches of immature cohos by the seiners allow them to take the first quarter of their catch in some two weeks; the trollers require approximately two months to take 25 percent of their catch, since they are fishing primarily for king salmon during the early part of the season. During the remainder of the coho run, the curves of both types of gear are very similar.

SPORT FISHING

King and coho salmon have provided popular sport fishing in the region for many years. With the exception of fly-fishing in a few restricted localities, this fishery has been carried on entirely by trolling, or by modifications of this gear, hence catches of other species of salmon are rare.

Collins (1892) referred to trolling for salmon as a recreation, saying:

> In autumn, when salmon are most numerous in the Sound, Seattle Bay is literally covered with pleasure boats for days in succession.

Rathbun (1899) mentions sport trolling for king and coho, either with spoons or bait, and also refers to good fishing in the spring for king salmon in the pools of such rivers as the Nanaimo and Cowichan. At the present time the Campbell River is best known for fly-fishing for kings, and many cohos are taken by this method at the mouth of the Cowichan River.

Throughout the southern part of the region the greater part of the spring and summer king-salmon catches, and a considerable number of coho catches, are made with "spinning" gear. This is a highly specialized development of trolling, and consists of fishing from an anchored boat with a rod, light line, and small hook. The bait is a spinner which is usually cut from fresh herring. In use, the line is cast from the boat, allowed to sink almost to the bottom, and then recovered by drawing it in with successive pulls, allowing the recovered line to coil in the bottom of the boat. The largest kings are landed in a few favorable places by trolling with "plugs" somewhat similar to those used in bass fishing.

The bulk of the sport catches on the sound consist of coho salmon, and these are most frequently taken by trolling with spoons, although many fishermen use cut herring or candlefish. Mature cohos are taken in the fall on copper spoons which are nickelplated on one side.

Although sportsmen fish in nearly all the inner waters of the region and as far out in the Strait of Juan de Fuca as Port Angeles and Victoria, the most heavily fished waters are in the region of Whidbey Island and the lower part of Puget Sound. Many resorts located in this region have 50 or more boats available for rental, and several thousand sportsmen fish from early spring to fall. Fishing is conducted in places such as Elliot Bay at Seattle throughout the entire year.

This sport has become increasingly popular in recent years, and the outfitting of fishermen, together with the rental of boats and sleeping quarters, may now be ranked as one of the fishing industries of the region.

SOCKEYE SALMON

By George A. Rounsefell

INTRODUCTION

The Fraser River, with its numerous tributary streams and chains of lakes, is potentially the best sockeye river in the world. Over a period of 24 years, six generations, from 1894–1917, it produced 195,740,000 sockeyes; an annual average of 8,160,000. The Kvichak River, flowing into Bristol Bay, ranked next, producing, during the same period, 155,330,000 sockeyes, an annual average of 6,470,000. The production of the Nushagak River, also flowing into Bristol Bay, was 78,010,000, with an annual average of 3,250,000. The river ranking fourth in North America was the Karluk, on Kodiak Island, with a production of 47,700,000 fish and an annual average of 1,990,000.

This comparison cannot be made over a longer period of time because in the earlier years none of these rivers were fished with sufficient intensity for the catch to be any measure of the size of the run, and in later years the Fraser River runs were so depleted by the blocking of the river at Hell's Gate in 1913 and 1914, and the intense fishing of the War years, that the catches have no longer given any measure of the productive capacity of the river.

From an annual average catch of 8,160,000 sockeyes for the 24-year period from 1894–1917, the production of the Fraser River, for the 17-year period from 1918–34, has fallen to an annual average of 1,830,000. The consequent annual loss to the fishermen of several millions of sockeye, through the failure of sufficient adult salmon to reach the spawning grounds, is a waste of the potential capacity of this great river. Such a waste of a natural resource, although less obvious, is just as real as the needless burning of thousands of acres of forest.

GENERAL LIFE HISTORY

SPAWNING

The sockeye, unlike the other four species of Pacific salmon in this region, rarely spawns elsewhere than in a tributary of a lake, or in gravel provided with spring seepage within a lake. Sockeyes spawn in one or another of the vast Fraser River lake systems from August until December, spawning, in general, being earlier in the Nechako River and Stuart-Trembleur-Takla lake systems and later below Hell's Gate and in the tributaries of the Thompson River, although a lake system may have both an early and a late run of sockeyes during the same season, forming two spawning peaks.

The fry, after absorption of the yolksac, wriggle free from the gravel, usually during the spring and summer months. Those that are hatched in the tributaries of the lakes find their way downstream into the lakes. In some localities a considerable portion of the adult run may occasionally spawn in the sluggish outlet stream of a lake. Whether or not the fry, upon hatching, ascend the slow-moving stream into the lake is not known, but it would appear probable that such may be the case.

Young sockeyes spend varying lengths of time in lakes before descending to the sea. In the Fraser River the majority of the young migrate in their second year.

From scale reading (Clemens, 1934) it appears that approximately 91 percent of the returning adults had left the lakes in their second year, 5 percent in their third year, and 4 percent in their first year. Foerster (1929b, 1934) shows that from the 1925 spawning at Cultus Lake, 6.2 percent of the migrants were in their first year (fry), 92.9 percent were in their second year (yearlings) and 0.9 percent were in their third year.

AGE AT MATURITY

The majority of the sockeyes of this region reach maturity and return from the ocean to their spawning grounds in their fourth summer. From 1920–33, inclusive, a period of 14 years, the ages of the sockeyes taken by the traps near Sooke, on Vancouver Island, (Clemens, 1934) have averaged as follows: 3-year-olds, 3.2 percent; 4-year-olds, 76.4 percent; 5-year-olds, 19.6 percent; and 6-year-olds, 0.6 percent. Since the proportion of the fish at each age varied considerably in different parts of the season, these figures are only an approximation of the number of fish at each age composing the catch, but they show the preponderance of 4-year-olds.

The cycle, or generation of sockeyes occurring quadrennially in the year following leap year (1909, 1913, 1917, etc.) was, as is shown below, tremendously abundant up to 1913, and fairly abundant in 1917, but much less abundant in 1921 and later years. Gilbert (1914) showed that the sockeyes running in 1913 were 99.5 percent 4-year-olds. In 1917 they were 94 percent 4-year-olds. In the past 4 years of this cycle (Clemens 1934) they have averaged but 77.4 percent 4-year-olds.

There is reason to believe that the change in the proportion of sockeyes 4 and 5 years of age is caused, at least in part, by changes in the proportion of the runs coming from different lake systems. This was pointed out by Gilbert (1917), who said that the runs to the various tributaries did not show the same proportions of 4- and 5-year-olds as did the samples of the run as a whole, the 5-year-olds being especially prominent in many localities below Hell's Gate.

During May and early June a run of sockeyes occurs that contains a large proportion of 5-year-old fish. This run is too small to be of any importance, as can readily be seen from the trap curve of seasonal occurrence (fig. 11), and is distinguished by the small size of the individuals, the lack of oil, and light-colored flesh. Since these fish lose most of their color in the canning process, they are usually sold as cohos.

Some of these very early sockeyes may be Skagit River fish, which are taken in late June along West Beach, but the larger part are probably bound for the Fraser River, as the traps in Rosario Strait, Lummi Island, Boundary Bay, and Point Roberts Areas all take them, and in about the same amount as the traps in the Salmon Banks and South Lopez Areas.

A third group of sockeyes that merit attention are the "grilse." These fish, usually males, have migrated to the ocean at the usual time, in the second year, but have matured precociously, returning after only 1 year in the sea, instead of the customary 2 years. On the years that preceded the former big years grilse were always numerous. Gilbert (1913, 1916) estimated them at 21.5 percent of the run in 1912, and 10 percent in 1916. The presence of these small sockeyes on such years was well-known to the cannerymen. On years preceding the off years the percentage of grilse in the run was quite small; very often negligible.

SOCKEYE RIVERS OF THE REGION

OUTER COAST STREAMS

In order to determine whether or not one is justified in regarding practically all of the sockeyes caught on Swiftsure Bank, in Puget Sound, and in the Gulf of Georgia as originating in the Fraser River, it has seemed advisable to show the extent of the runs to other sockeye streams in the region and to discuss the probability of any of these sockeyes being included in the records as Fraser River fish.

The largest run of sockeyes on the outer coast, immediately south of Puget Sound, is that of the Quinault River, which enters the ocean 65 miles south of Cape Flattery. The runs appear to fluctuate from about 50,000 to 500,000 sockeyes, as shown in table 25.

The Indians commence catching a few sockeyes at the mouth of the river as early as January, the bulk of the run reaching Quinault Lake between May 20 and July 7, and the mode occurring in the week ending June 9. In the 1922–24 runs, for which accurate weir counts by the Bureau of Fisheries are available, 77 percent had entered the lake by June 30. Of the remaining 23 percent there is reason to suppose that most of them were already in the river by this date, as fishing at the mouth of the river is usually practically over by July 1. The sockeyes run considerably later, however, on Swiftsure Bank, the seiners taking almost none before July 1 and the season not reaching its height until early in August.

TABLE 25.—*Quinault River sockeye (blueback) run, 1908–34*

Year	Pack in cases [1]	Actual catch	Escapement	Year	Pack in cases [1]	Actual catch	Escapement
1908		[2] 75,000		1921	2,590		[4] 20,000
1909				1922	19,213	265,649	248,935
1910	4,350			1923	10,454	138,148	174,602
1911	2,031			1924	8,473	104,571	136,774
1912	4,700			1925	3,313	54,000	19,395
1913	712			1926	1,729		
1914	12,274			1927	5,260		
1915	24,484	[3] 355,007		1928	2,000		
1916	10,315			1929	4,449		
1917	4,608			1930	21,536		
1918	2,490			1931	8,476		
1919	1,244	14,947		1932	14,263		
1920	235			1933	6,754		
				1934	4,960		

[1] 1910–28 from Cobb (1930, pp. 559–560), 1929–35 from Pacific Fisherman.
[2] New York Sun, July 19, 1908. It also states: "This is 27,000 more fish than have ever been caught in any previous season."
[3] From Cobb (1930, p. 426).
[4] Only 11,786 counted, balance estimated.

The Ozette River (fig. 1) empties into the ocean 12 miles south of Cape Flattery. The Bureau of Fisheries placed a weir across this river in 1926, discovering that the run, which is nearly over by July 1, amounted to only a few thousand fish.

The Hobarton River empties into Nitinat Inlet, which reaches the ocean just north of the entrance to the Strait of Juan de Fuca. The Nitinat Inlet sockeye catch is given in the Fisheries Reports of the Dominion of Canada as follows: 12,000 in 1928, 20,130 in 1930, 16,487 in 1931, and 56,000 in 1932.

Barclay Sound, (fig. 1) a little farther to the north, has two runs of sockeyes, one ascending the Anderson River, which is 18 miles from Cape Beale, and the other the Somass River at the head of Alberni Canal, a northeasterly extension of Barclay Sound that cuts deeply into Vancouver Island.

The Anderson River spawning escapement has been estimated from 1925–34 in the Dominion Reports. The lowest escapement was 7,500 in 1933, the highest 135,000 in 1929, with an average for the 9 years of 55,000 sockeyes. In the only 2 years for which figures are given, 1928 and 1932, the catch was 15,000 and 28,000 respectively. The total annual run may therefore be considered as approximately 75,000.

The run to the Somass River appears to be larger. The Stamp River falls were formerly difficult for sockeye to ascend, most of the run to the Somass River spawning in Sproat Lake. In 1927, a permanent fishway was constructed, so that the run now spawns in Sproat Lake, Great Central Lake and Ash Lakes; all of considerable extent. The Reports of the Dominion give the catch of Somass River sockeyes as 24,000 in 1928, 47,860 in 1930, 77,000 in 1932, 60,000 in 1933, and 75,000 in 1934. The escapement is unknown but, if we assume it was 50 percent, the run since 1932 has been close to 150,000.

The annual run then to Barclay Sound appears to total in the neighborhood of 225,000 sockeyes. That a few of these fish may be captured on Swiftsure Bank is not impossible and it is unlikely that this can be adequately determined until such time as sockeyes are tagged on the bank.

PUGET SOUND STREAMS

The Skagit River, the only sockeye stream in the Puget Sound area, is no longer an important producer of sockeye salmon although it once supported a fair run. The Baker Lake sockeye hatchery, built in 1896 by the State of Washington on the Baker River, tributary to the Skagit, was bought by the Bureau of Fisheries in 1899 and has operated continuously since. The records of this station previous to 1916 were burned, but the remainder have been available.

The annual escapement to Baker River from 1898–1901 was estimated at 20,000 sockeyes. Within a few years the run had become somewhat reduced, and by 1916 the escapement was about 5,000 sockeyes per year. The escapement of 14,558 in 1924 was due to the closing of the salmon traps in the waters east of Whidbey Island during that season. The building of the Baker River dam destroyed all but 40 fish of the 1925 run, but since then the greater portion of those reaching the dam has been caught and hoisted over.

This small run of sockeyes is distinguished from that of the Fraser River by the season of its migration. The traps east of Whidbey Island, which catch only Skagit River sockeye, commence taking them by the first of June. The run, which reaches its peak during the last week in June or occasionally the first week in July, and is practically over by July 20, averages about a month earlier than that to the Fraser River. The traps on West Beach usually show two modes in their sockeye catches; a small early mode due to Skagit River fish and a later one when the bulk of the Fraser River sockeyes are migrating.

GULF OF GEORGIA STREAMS

The only sockeye stream in the Gulf of Georgia proper is Saginaw Creek (see fig. 1). The 1926 catch, mentioned as being very small, was reported as 3,000 sockeyes, while the escapement was estimated as between 18,000 and 19,000 fish.

Just north of the Gulf of Georgia proper, there are small runs of sockeyes to several streams, the chief being the run to Phillips Arm, which is practically over before the run of Fraser River fish makes its appearance.

MIGRATION IN SALT WATER

Tagging experiments (O'Malley and Rich, 1919) have shown that the sockeyes entering through the Strait of Juan de Fuca strike the Salmon Banks and pass along the southern shore of San Juan and Lopez Islands, and, to a slight extent, the western shore of Whidbey Island, thence past Lummi Island, Whitehorn Point, Boundary Bay and Point Roberts to the mouth of the Fraser River. A few migrate north through Haro Strait

Another tagging experiment (Dominion Report for 1929–30, p. 155; 1930), indicates that the run of sockeyes which enters the northern end of the Gulf of Georgia through Discovery Passage is bound chiefly for the Fraser River. Out of 519 sockeyes tagged at Deepwater Bay in Discovery Passage, 107 were recaptured. The 17 recaptured at the point of tagging must be disregarded. Out of the remaining 90 a total of 82 fish, or 91 percent, were recaptured either in the Fraser River or at Point Grey (7 fish) just at the mouth of the river.

TOTAL PACK OF THE FRASER RIVER SYSTEM

The first real sockeye cannery was built at New Westminster in 1866 but no pack records are available for the first 7 years of the industry. The pack of 1873 was 8,125 cases (Rathbun 1899). The packs of 1874 and 1875 are unknown, but figures are available since 1876. The annual sockeye packs of the Fraser River system are given in table 26.[5]

The Canadian fishery is much older than the American, reaching 100,000 cases by 1878 and 300,000 cases by the big sockeye year of 1889. By 1896 the Canadians had packed a total of 3,209,000 cases against 254,000 cases by the American operators. However, the introduction of traps in the early 1890's gave a great impetus to the industry in Puget Sound. From 1898–1934, a 37-year period, the Canadian pack was larger than the American in only 6 years: 1903, 1905, 1906, 1915, 1922, and 1926.

Up to the end of 1934 the packs of both countries aggregated the amazing sum of 21½ million cases of sockeye, of which the Canadians had packed 10,773,000 cases, the Americans, 10,721,000 cases.

[5] In compiling these data several sources have been used: The Dominion of Canada reports (1882–1934), the reports of the British Columbia Commissioner of Fisheries (1901–34), the Washington State reports (1890–1934), the Pacific Fisherman annual numbers (1903–34) and reports by the U. S. Bureau of Fisheries in various years from 1893 to 1934; as well as much unpublished material including printed tabulations of the pack by companies, prepared by R. P. Rithet & Co., Ltd., Victoria, B. C. for 1900; Fraser River Canner's Association (1904–8); British Columbia Salmon Canners Association, and since 1923 by the canned salmon section of the Canadian Manufacturers' Association. Material for recent years has been supplied by the Office of the Chief Supervisor of Fisheries for British Columbia and by the State of Washington Fisheries Department. In the earlier years the published reports of the packs are not segregated according to species and for these years we have made use of very extensive and careful notes kept by Henry Doyle of Vancouver, B. C. In addition, original records of various operators have been available.

TABLE 26.—*Sockeye pack of Fraser River system, in 48-pound cases*

Year	Cases canned			Year	Cases canned		
	Fraser River [1]	Puget Sound [2]	Total		Fraser River [1]	Puget Sound [2]	Total
1873	8,125		8,125	1906	185,440	182,241	367,681
1876	9,847		9,847	1907	65,061	96,974	162,035
1877	64,387		64,387	1908	79,211	170,951	250,162
1878	100,000		100,000	1909	585,935	1,102,399	1,688,334
1879	50,000		50,000	1910	151,595	248,041	399,636
1880	25,000		25,000	1911	64,470	127,761	192,231
1881	142,516		142,516	1912	124,967	184,680	309,647
1882	175,000		175,000	1913	739,601	1,673,099	2,412,700
1883	100,000		100,000	1914	201,498	335,230	536,728
1884	25,000		25,000	1915	95,407	64,584	159,991
1885	89,617		89,617	1916	35,070	84,637	119,707
1886	36,000		36,000	1917	154,415	411,538	565,953
1887	125,000		125,000	1918	21,598	50,723	72,321
1888	40,000		40,000	1919	38,854	64,346	103,200
1889	303,875		303,875	1920	49,184	62,654	111,838
1890	225,000		225,000	1921	41,731	102,967	144,698
1891	131,000	12,000	143,000	1922	54,829	48,566	103,395
1892	59,000	15,000	74,000	1923	34,574	47,402	81,976
1893	455,000	47,852	502,852	1924	39,732	69,369	109,101
1894	360,000	41,300	401,300	1925	36,954	112,023	148,977
1895	360,000	65,143	425,143	1926	86,765	44,673	131,438
1896	325,000	72,979	397,979	1927	65,154	97,594	162,748
1897	850,000	312,048	1,162,048	1928	30,128	61,044	91,172
1898	216,000	252,000	468,000	1929	60,823	111,898	172,721
1899	486,409	512,500	998,909	1930	103,662	352,194	455,856
1900	172,617	229,800	402,417	1931	40,947	87,211	128,158
1901	974,911	1,106,643	2,081,554	1932	69,792	81,188	150,980
1902	295,679	372,301	667,980	1933	54,146	128,518	182,664
1903	204,848	167,211	372,059	1934	139,276	349,602	488,878
1904	73,175	123,419	196,594				
1905	838,813	837,122	1,675,935	Grand total	10,772,638	10,721,425	21,494,063

[1] Includes packs at Victoria, Quathiaski, and points in the Gulf of Georgia. Quathiaski packs not available for 1931 and 1934.
[2] Includes 4,495 cases packed at Grays Harbor and the Columbia River in 1909 (see Cobb, 1930).

Some idea of the former abundance of the sockeyes can be gained by noting that in 4 years of the former big-year cycle the pack was in excess of 1,675,000 cases, and, in 1901 and 1913, it was over 2,000,000 cases.

METHOD AND LOCALITY OF CAPTURE

INDIAN FISHING IN THE FRASER

The Indians fishing in the Fraser River, except commercially, have depended largely on dip nets, gaffs, set nets, and spears. Dip nets are used chiefly in the larger rivers at points where the salmon have difficulty in ascending, such as Hell's Gate canyon; the canyon of the Fraser just above the mouth of Bridge River; Fish Canyon, Hanceville and Indian Bridge on the Chilcotin River, and at Fort George on the Nechako River above its confluence with the Fraser River (fig. 25). The fishing at both Hell's Gate and Bridge River canyons is much more successful during seasons of low water when the salmon have greater difficulty in passing. Set nets are used but slightly, not being practical in swift water. Spears are for use in the smaller tributaries, especially on the spawning grounds. Gaffs are mentioned in the 1917 report of the B. C. Commissioner of Fisheries as being used, along with dip nets, at Bridge River canyon.

At one time the salmon were also taken by barricading the streams. The fishing in the streams near Stuart Lake in 1830 is thus described by John McLean (Wallace, 1932) who says that the natives built weirs of stakes and brush and caught the salmon in wicker baskets as they swam through openings in the weirs.

In addition to catching the adult salmon the Indians formerly caught large quantities of the young sockeyes on their migration from the lakes to the sea. John P. Babcock (Report of the Fisheries Commissioner for British Columbia for the year 1903) describes how the Indians had built a dam of rocks and brush across a stream in the form of a great funnel with a basket trap at the lower end. Besides those caught in the trap many thousands were destroyed by becoming entangled in the brush.

EXTENT OF THE INDIAN FISHERY

Salmon fishing on the Fraser River was always carried on by the Indians, who consumed large quantities of fresh salmon and dried larger quantities for their own use and for barter with the tribes of the hinterland. Those living near the mouth of the river obtained some of all species of salmon, but the Indians dwelling nearer the headwaters depended chiefly on sockeye, and a few king salmon. The extent of this fishing is rather difficult to determine. At some points, such as Bridge River, Kamloops, Stuart Lake, Hell's Gate, Pemberton, and the Chilcotin River, large catches were made in good years (see fig. 25).

Fishery officials have made many estimates of the Indian catch at the chief fishing camps by counting the numbers of salmon on the drying racks. According to their reports the sockeye catch at Bridge River in big years averaged 40,000. For the Chilcotin River system the catches of 1905 and 1909 were also estimated at 40,000, the catch of 1908 at over 20,000, and that of 1913 at 25,000. Of the Lillooet River, Crawford (13th Annual Report of the State Fish Commissioner (Washington) 1902) says:

> Every year the Indians gather here to secure their salmon for the winter and thousands of sockeyes are taken and dried every season. One Indian speared seventy sockeyes in two hours, the first day I was there.

A toll of between 400,000 and 500,000 sockeyes in the former big years is a conservative estimate of the Indian catch. Even as late as 1929, with a greatly reduced abundance, as well as a much smaller Indian population, an accurate estimate showed that they caught 48,000 sockeyes, 20,000 kings, 25,000 cohos, 4,500 pinks, and 6,500 chums (Dominion Report, 1930). During years of poor sockeye runs the Indians living on tributaries where the runs failed were often on the verge of starvation, so complete was their dependence on the salmon for their livelihood. This was the case at Stuart Lake in 1841 and at Alexandria, on the Fraser River between the mouths of the Chilcotin and the Quesnel Rivers, in 1855 (Morice, 1904).

CATCH BY COMMERCIAL GEAR

In determining the number of sockeyes captured by the various methods in the different localities, the records of the actual number of sockeyes taken have been used wherever possible, and where these have not been available the number of cases canned has been converted into number of fish.[6]

[6] The number of sockeyes required to fill a 48-pound case of cans varies considerably from year to year, so that the use of the same conversion factor year after year would not give the best results. From two Canadian and two United States canneries we have obtained records covering 23 years, of the number of sockeyes required to fill a case. This varies from about 10 to 13 fish per case, tending to be higher in the earlier years, especially on the years of the big run. For years in which no conversion data were available we have used the average conversion factor of the other years of the same 4-year cycle, as the size tends to be the same from one cycle to the next. This is probably on account of the differences in size of the sockeyes spawning in the different lake systems, as the various lakes do not contribute equally to the runs of each cycle.

Table 27 shows the annual catch by the principal forms of gear. The total commercial take of sockeye from 1873–1934 comes to 253½ million, of which 116½ million, or 46 percent, have been caught by gill nets in, or off the mouth of the Fraser River. The traps, both Canadian and American, account for 94 million, or 37 percent, and of the remaining 17 percent, 14 percent were taken by purse seines and 3 percent by miscellaneous gear. The miscellaneous included most of the fish caught at Quathiaski, as well as fish taken by minor Puget Sound gear such as gill nets, set nets, drag seines, and reef nets. Approximately 5 million of the trap fish and one-half million of the purse seine fish were taken by Canadian gear, so that, if the miscellaneous gear is ignored, the catches total 122 million by Canadian gear and 124 million by United States gear.

The slight difference in pack in favor of the Canadians was due largely to shipments of fresh sockeye from Puget Sound waters to the canneries on the Fraser River, outweighing shipments in the other direction. In the early days the canning facilities on Puget Sound were too limited to handle the catch, and the Fraser River canneries were much closer to the sockeye fishing grounds. In 1894 the Canadians placed an embargo on the shipment of fresh sockeye out of the Province. This embargo, however, was not always in effect. In 1905, for instance, over 2 million pounds of late-run sockeyes were shipped from the Fraser River to Puget Sound canneries.

TABLE 27.—*Sockeye catch of the Fraser River system by various types of gear*

Year	Fraser River gill nets	Purse seines		Traps	Miscellaneous gear	Total
		Territorial waters	High seas [1]			
1873	100,839					100,839
1874	(?)					(?)
1875	(?)					(?)
1876	107,332					107,332
1877	799,107					799,107
1878	1,077,000					1,077,000
1879	571,350					571,350
1880	272,500					272,500
1881	1,768,766					1,768,766
1882	1,884,750					1,884,750
1883	1,142,700					1,142,700
1884	272,500					272,500
1885	1,112,257					1,112,257
1886	387,720					387,720
1887	1,428,375					1,428,375
1888	433,000				3,000	436,000
1889	3,651,393				120,000	3,771,393
1890	2,263,250				160,000	2,423,250
1891	1,296,937			[2] 344,000	[2] 200,000	1,840,937
1892	543,100			300,000	[2] 100,000	943,100
1893	5,397,005	[2] 100,000		371,356	[2] 372,535	6,240,896
1894	3,737,200	[2] 150,000		[2] 200,000	[2] 194,801	4,282,001
1895	4,033,720	6,002		903,852	207,183	5,150,757
1896	3,120,523	[2] 200,000		[2] 694,314	[2] 283,134	4,297,971
1897	9,959,350	[2] 600,000		[2] 3,128,486	[2] 734,342	14,422,178
1898	2,293,715	[2] 300,000		2,230,143	[2] 216,502	5,040,360
1899	4,514,385	804,681		5,610,418	438,759	11,368,243
1900	1,873,981	[2] 400,000		[2] 1,722,508	[2] 389,856	4,386,345
1901	11,792,692	[2] 1,000,000		[2] 12,457,957	[2] 509,382	25,760,031
1902	3,142,814	[2] 800,000		[2] 2,736,657	[2] 499,784	7,179,255
1903	2,338,987	[2] 400,000		[2] 1,252,012	[2] 261,620	4,252,619
1904	742,081	254,657		1,239,069	163,264	2,399,071
1905	10,143,517	[2] 1,374,745		[2] 8,662,974	[2] 500,000	20,681,236
1906	1,983,698	[2] 500,000		1,505,854	107,602	4,097,154
1907	584,033	[2] 200,000		[2] 903,807	[2] 33,729	1,721,569
1908	707,011	[2] 325,574		[2] 1,667,295	[2] 50,000	2,749,880

[1] High seas catch 1925–1934 from U. S. Fishery Industry reports, before that from our data, plus sockeye canned at Neah Bay. Some taken before our records.

[2] Estimated: From 1900 to 1912 the U. S. trap catch equals our data plus 20 percent, from 1896 to 1898 plus 50 percent, 1894 purely an estimate, and 1891 equals our data times 2.

TABLE 27.—*Sockeye catch of the Fraser River system by various types of gear*—Continued

Year	Fraser River gill nets	Purse seines		Traps	Miscellaneous gear	Total
		Territorial waters	High seas			
1909	4,869,134	3,484,799		12,026,263	546,278	20,926,474
1910	1,459,297	[1] 1,060,558		[1] 1,905,962	[1] 30,000	4,455,817
1911	659,496	[1] 392,300		[1] 1,101,837	[1] 25,000	2,178,633
1912	1,185,746	[1] 269,603		[1] 1,877,945	[1] 30,000	3,363,294
1913	8,761,249	10,049,295		12,493,687	38,808	31,343,039
1914	2,035,630	1,344,004		2,276,554	36,879	5,693,067
1915	1,050,672	244,693		456,542	73,556	1,825,463
1916	311,196	150,446		768,369	56,305	1,286,316
1917	1,402,327	1,989,191		3,292,193	199,690	6,883,401
1918	197,352	45,073	2,495	538,903	27,546	811,369
1919	368,395	286,365	25,365	539,618	29,125	1,248,868
1920	486,118	53,083	828	656,917	12,783	1,209,729
1921	433,852	221,152	35,820	915,313	80,104	1,686,241
1922	514,249	88,277	5,157	436,848	49,461	1,093,992
1923	300,115	142,355	5,717	370,874	37,892	856,953
1924	372,333	99,098	25,931	680,554	36,390	1,214,306
1925	397,386	287,329	142,224	975,252	26,525	1,828,716
1926	891,045	90,523	14,286	355,848	30,764	1,382,466
1927	643,254	435,693	50,000	586,944	62,596	1,783,487
1928	267,457	61,716	19,770	566,280	26,460	941,683
1929	605,170	368,155	102,134	926,939	56,780	2,059,178
1930	964,987	2,504,978	144,278	908,066	65,723	4,588,032
1931	450,532	316,141	217,015	444,366	5,585	1,433,639
1932	657,222	353,849	19,579	510,113	46,378	1,587,141
1933	546,026	541,505	121,061	1,198,887	42,957	2,450,436
1934	1,230,986	1,716,055	674,716	1,391,104	7,497	5,020,358
Total	116,543,814	34,011,888	1,606,376	94,132,880	7,226,575	253,521,533
Percent	46	13	1	37	3	100

[1] Estimated: From 1900 to 1912 the U. S. trap catch equals our data plus 20 percent, from 1896 to 1898 plus 50 percent, 1894 purely an estimate, and 1891 equals our data times 2.

LOCALITY OF TRAP CATCHES

In addition to the locality segregation given in the foregoing table, the following detailed analysis of the locality of capture of the trap fish shows the relative importance of each fishing district in Puget Sound. Since records were obtained for about 82 percent of all of the trap-caught sockeyes, 100 percent from 1915 to 1934, inclusive, the figures given in table 28 may be considered representative of all of the 94 million taken by this method.

LOCALITY OF PURSE-SEINE CATCHES

Of the 35½ million taken in purse seines, 1½ million are definitely assigned to extraterritorial waters off the mouth of the Strait of Juan de Fuca. The locality of capture of the remainder cannot be as easily established as in the case of those caught by traps. The principal sockeye seining grounds are the Salmon Banks and Point Roberts Areas, with lesser amounts from Rosario Strait, Haro Strait, Lummi Island, Birch Bay and Boundary Bay Areas, and a very few from West Beach.

Data from companies buying purse seine fish show that during the 4-year period covering a year of each sockeye cycle, from 1931–1934, about two-thirds of the seine-caught sockeyes were taken on the Salmon Banks. This includes the Salmon Bank and South Lopez Areas. Of the remainder the larger share were caught at Point Roberts, with lesser amounts from Rosario Strait, Lummi Island, and Haro Strait Areas.

TABLE 28.—*Sockeye catch by traps in different areas, 1893–1934* [1]

Year	Areas in which caught						
	North of Sandy Point [1]	Sandy Point to Deception Pass	West Beach and Ebeys Landing	Strait of Juan de Fuca [1]	East of Whidbey Island and south of Point Wilson	Undetermined	Total
1893	185,678						185,678
1894							
1895	600,957						600,957
1896	454,831	8,045					462,876
1897	1,904,593	208,191	2,873				2,115,657
1898	1,482,549	15,081					1,497,630
1899	3,247,248	832,680					4,079,928
1900	1,098,886	324,505	7,148		6,142		1,436,681
1901	7,931,801	1,864,905	21,925		6,411	595,388	10,420,430
1902	1,573,961	687,050	19,907		4,089		2,285,007
1903	775,692	245,923	22,214				1,043,829
1904	728,780	205,141	5,119	50,000			989,040
1905	5,039,241	1,517,262	238,906	524,535	2,897		7,322,841
1906	832,147	338,049	20,348	72,357	4,037		1,266,938
1907	455,356	208,059	27,749	70,822	2,990		764,976
1908	1,004,494	253,066	22,485	128,218	2,519		1,410,782
1909	5,789,782	2,306,825	212,033	725,736	1,377		9,035,753
1910	991,026	391,156	21,819	218,461	2,250		1,624,712
1911	572,511	287,167	6,541	59,212	2,635		928,066
1912	911,978	488,636	24,118	164,536	3,109		1,592,377
1913	6,011,680	3,080,543	100,027	881,123	1,350		10,074,723
1914	968,885	683,530	153,991	171,078	1,213		1,978,697
1915	240,670	149,264	27,572	26,506	11,046	1,484	456,542
1916	386,446	278,566	39,765	55,550	6,581	1,461	768,369
1917	1,584,230	1,091,186	164,683	437,175	4,197	10,722	3,292,193
1918	220,785	233,426	33,382	48,312	2,938	60	538,903
1919	284,714	142,805	17,136	86,608	8,331	24	539,618
1920	307,707	258,877	34,496	45,416	9,441	980	656,917
1921	476,128	347,135	38,713	46,508	6,208	621	915,313
1922	220,710	152,200	24,203	38,393	1,342		436,848
1923	168,851	161,238	9,115	28,365	3,305		370,874
1924	382,755	232,610	17,410	45,933	1,846		680,554
1925	543,310	338,279	34,279	52,897	6,594		975,309
1926	192,818	129,592	6,389	25,324	1,720	5	355,848
1927	322,282	203,828	7,853	51,383	1,598		586,944
1928	308,092	204,315	18,156	33,812	1,905		566,280
1929	488,018	328,918	54,851	46,564	4,062	4,526	926,939
1930	488,386	323,461	35,503	58,184	2,532		908,066
1931	206,338	184,492	18,332	31,150	4,054		444,366
1932	236,248	202,470	19,716	48,843	2,836		510,113
1933	510,053	539,848	25,137	122,349	1,500		1,198,887
1934	821,737	469,463	27,507	69,751	2,646		1,391,104
Total	50,952,364	19,917,787	1,561,401	4,465,101	125,701	615,271	77,637,615

[1] North of Sandy Point includes Canadian traps in Boundary Bay; the Strait of Juan de Fuca includes Canadian traps near Sooke and American traps west of Point Wilson. From 1915–34 our data include all trap-caught sockeye. All but portions of the Sooke data are actual numbers of fish, not converted figures.

During the late sockeye run of 1934, seining was permitted from September 1–8 in the portion of seining area 17 directly off of the mouth of the Fraser River, and 328,000 fish were taken. Small amounts of sockeyes are sometimes seined around Pender Island in seining area 18. In 1930 this area produced 31,000 sockeyes, in 1931, 3,000, and in 1934, 45,000.

CHANGES IN ABUNDANCE OF DIFFERENT PORTIONS OF THE RUN

The gill nets have been used as giving the best measure of the change in the time of the run. The average gill net delivery for each 7-day period was derived by combining the averages for each year and dividing by the number of years with data (see table 29).

The curves for the 12 early years, 3 sockeye cycles, and for the 12 late years are shown in figure 22. For the 12 early years sockeye fishing usually terminated on August 25, although considerable fishing was carried on during the heavy fall runs of 1905 and 1909. No data are available for the fall of 1905, but those for 1909 are shown in figure 22.

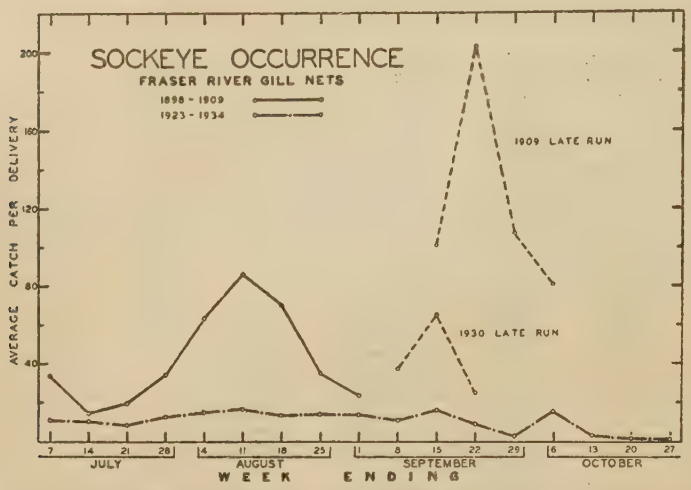


FIGURE 22.—Occurrence of sockeye as shown by Fraser River gill-net catches. Note the peak in the week ending August 11 in the three early cycles (1898–1909), which is entirely missing in the three late cycles. The late runs of 1909 and 1930 are also shown. The big years of 1901, 1905, 1909, and 1913 were characterized by a second heavy run coming late in the fall.

Because of the lack of fall fishing during most of the earlier years it is often thought that there were no abundant late runs in those years, but the figure shows plainly that the late run of 1909 was many times as abundant as that of 1930, the most abundant of the late runs during the last 12 years.

That some sockeye were ordinarily present in the river after the usual cessation of fishing on August 25, during the years before we have accurate records, is indicated by Rathbun (1899, p. 270) who says:

> . . . the average fishing season ends somewhere about the 20th to the 25th of August, and years are recalled when nothing could be done after the first week of that month. Small numbers usually continue present during more or less of the early part of September, but with the near approach of the spawning period the fish rapidly deteriorate in appearance and condition and lose their commercial value.

TABLE 29.—*Change in seasonal occurrence of sockeyes between early and late years in Fraser River gill nets*

Week ending	1898 to 1909		1923 to 1934		Week ending	1898 to 1909		1923 to 1934	
	Number of years with data	Average catch per gill net delivery	Number of years with data	Average catch per gill net delivery		Number of years with data	Average catch per gill net delivery	Number of years with data	Average catch per gill net delivery
July 7	3	33.34	5	10.83	Sept. 22	1	202.90	7	9.03
July 14	9	14.40	6	10.41	Sept. 29	1	107.32	4	3.09
July 21	10	19.73	12	8.44	Oct. 6	1	80.93	3	15.64
July 28	12	34.37	12	13.09	Oct. 13			3	2.77
Aug. 4	12	63.31	12	15.15	Oct. 20			2	1.63
Aug. 11	12	86.58	12	16.98	Oct. 27			2	1.44
Aug. 18	12	70.13	12	14.06					
Aug. 25	12	35.14	12	14.54	Number of fish		1,982,735		1,469,746
Sept. 1	4	23.41	12	14.17					
Sept. 8			12	11.10	Number catches		30,706		87,514
Sept. 15	1	101.52	12	16.60					

What has happened to the early runs is clearly shown by table 30, giving the average catches during the period from July 15–August 25, which embraces almost all

of the period usually fished during the earlier years. The decrease in abundance is astounding, the average of 14.85 sockeye per delivery during the later years being but 24 percent of the earlier average. Even if the former big-year cycle is omitted from both periods, the deliveries in the later period are only 32 percent of the earlier.

TABLE 30.—*Average catch per gill net delivery of sockeye on the Fraser River*

Years	Number caught July 15 to Aug. 25, inclusive	Number of deliveries	Average delivery	Years	Number caught July 15 to Aug. 25, inclusive	Number of deliveries	Average delivery
1898	38,636	1,240	31.16	1923	8,823	783	11.27
1899	76,910	1,201	64.04	1924	18,266	1,018	17.94
1900	38,208	1,172	32.60	1925	17,005	1,183	14.37
1901	186,797	1,345	138.88	1926	22,134	1,172	18.89
1902	45,736	607	75.35	1927	18,600	2,386	7.80
1903	164,058	3,640	45.07	1928	37,873	3,282	11.54
1904	64,867	2,845	22.80	1929	85,811	3,512	24.43
1905	724,000	4,901	147.72	1930	81,557	6,181	13.19
1906	128,484	2,237	57.44	1931	57,064	6,101	9.35
1907	71,292	3,062	23.28	1932	152,847	7,389	20.69
1908	129,662	3,872	33.49	1933	104,944	7,677	13.67
1909	201,467	2,598	77.55	1934	141,932	9,427	15.06
Sum			749.38	Sum			178.20
Average			62.45	Average			14.85
Average of "off" years			42.83	Average of "off" years			13.86

The most unfortunate feature in the depletion of the earlier-running sockeyes is the accompanying fall in the quality of the pack as a whole. Not only have the sockeyes been depleted, but worse, the depletion has been much heavier during the early run when the quality is of the best.

The late-running sockeyes have been encouraged by several circumstances; first, during the earlier years the late run was seldom fished on account of its inferior quality; second, the Fraser River closed season, which began on August 25 during most years, was a protection; third, the 10-day fall closed season in odd-numbered years from 1921–29, and in all years since 1930 in Puget Sound waters, has enlarged the escapement of the late-running fish. This serves to emphasize the fact, common to nearly all fisheries, that the most valuable portion of a population is usually the first to be destroyed.

CHANGES IN ABUNDANCE

Because the sockeye has always been the chief object of the gill net and trap fisheries, its abundance may be more accurately measured than that of the other species. The abundance of a salmon run cannot be measured in the same manner as that of a marine species for which each unit of gear may fish throughout the season upon the same general population. The salmon are running a gauntlet, each school avoiding capture as it approaches closer to its goal. Therefore, because variations in temperatures, currents, winds and tides cause changes in the rate and exact route of migration, the productivity of the different fishing areas may exhibit annual variations independent of those produced by the actual numbers of migrating sockeyes.

Conditions often favor one form of gear more than another, so that the availability of the schools to one method of fishing must not be accepted as the final criterion of

abundance without comparing it with the availability to other forms of gear. Also, the number of sockeyes caught on Swiftsure and Salmon banks is bound to influence the catches in Boundary Bay, and they aid in influencing the catches in the Fraser River.

The gill nets in the Fraser River, covering a restricted area, undoubtedly sample the portion of the run that escapes thus far more thoroughly than the traps and seines can hope to do. If the number and efficiency of the gill nets remained constant they might then give an adequate picture of the escapement, but, unfortunately, their number varies considerably.

To work out these complexities so as to allow for the difference in seasonal availability to different gear, the effect of one form of gear on the catch of another, the amount of competition between units of gear according to their numbers, and, finally, the changes in abundance of some races due to the difference in fishing intensity at different parts of the season, is beyond the scope of this report. General indices of abundance are presented for the major forms of gear and such general conclusions drawn as appear justified.

AVERAGE CATCH PER UNIT OF EFFORT WITH GILL NETS

The number of sockeyes actually captured by gill nets in the Fraser River, taking into consideration, whenever possible, fish shipped to and from the Fraser River, is given in table 31. This has been divided by the number of units of fishing effort and the results shown in figure 23.

In the earlier years the catch was often limited by the capacity of the canneries, and this continued in the big-year cycle up to 1913. Under these conditions the curve does not give a true picture of the actual early abundance which was undoubtedly somewhat higher.

TABLE 31.—*Catch per unit of effort by gill nets, 1877–1934*

Year	Number gill-netted	Total units of effort	Catch per unit of effort	Year	Number gill-netted	Total units of effort	Catch per unit of effort
1877	799,107	285	2,804	1907	584,033	2,942	199
1878	1,077,000	449	2,399	1908	707,011	2,410	293
1879	571,350	304	1,879	1909	4,869,134	4,634	1,051
1880	272,500	274	995	1910	1,459,297	2,745	532
1881	1,768,766	396	4,467	1911	659,496	2,350	281
1882	1,884,750	666	2,830	1912	1,185,746	2,476	479
1883	1,142,700	782	1,461	1913	8,761,249	4,369	2,005
1884	272,500	723	377	1914	2,035,630	4,621	441
1885	1,112,257	672	1,655	1915	1,050,672	4,663	225
1886	387,720	775	500	1916	311,196	4,299	72
1887	1,428,375	1,055	1,354	1917	1,402,327	4,849	289
1888	433,000	576	752	1918	197,352	3,049	65
1889	3,651,393	596	6,126	1919	368,395	2,600	142
1890	2,263,250	596	3,797	1920	486,118	2,545	191
1891	1,296,937	629	2,062	1921	433,852	2,702	161
1892	543,100	954	569	1922	514,249	2,548	202
1893	5,397,005	1,626	3,319	1923	300,115	1,768	170
1894	3,737,200	2,481	1,506	1924	372,333	1,768	211
1895	4,033,720	2,580	1,563	1925	397,386	1,689	235
1896	3,120,523	4,291	727	1926	891,045	1,810	492
1897	9,959,350	3,832	2,599	1927	648,254	2,010	323
1898	2,293,715	4,642	494	1928	267,457	2,092	128
1899	4,514,385	4,785	943	1929	605,170	2,312	262
1900	1,873,981	6,369	294	1930	964,987	2,375	406
1901	11,792,692	6,350	1,857	1931	450,532	2,163	208
1902	3,142,814	4,278	735	1932	657,222	2,289	287
1903	2,338,987	5,362	436	1933	546,026	2,598	210
1904	742,081	3,571	208	1934	1,230,986	2,745	448
1905	10,143,517	4,582	2,214				
1906	1,983,698	3,178	624	Total	116,335,643		

On account of economic conditions only six canneries operated in 1884 and 1885; but the number of licenses issued was as great as in years when double the number of plants were busy. Therefore, the low points of 1884 and 1885 should be regarded with suspicion, as the catch per net was obviously lowered by the inability of the canneries to utilize their full catching capacity. Eliminating these doubtful years, 1886 appears to be the low point of the early period.

Since about 1897 the whole curve is lower than would be the case were the whole sockeye population to have reached the river, as it did before the expansion of fishing in Puget Sound. Regardless, however, of all the factors that presumably affect the level of the curve to some extent the fall is far too pronounced to mean anything but depletion.

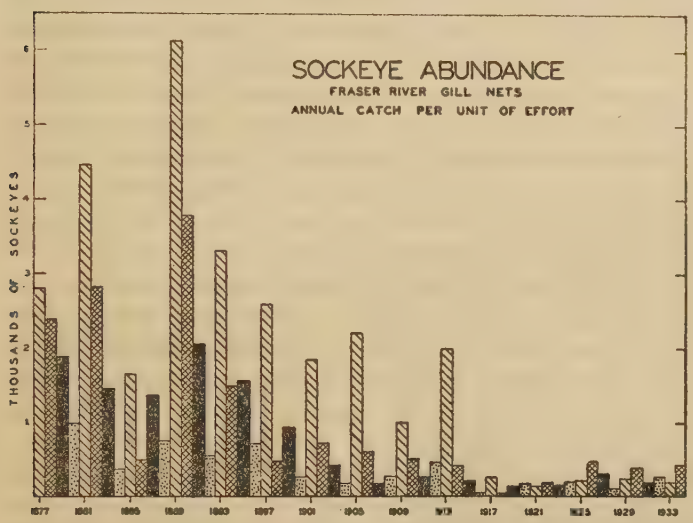


FIGURE 23.—Annual catch per unit of fishing effort of Fraser River gill nets for the 58-year period from 1877–1934. Note the decrease in the catch in each of the four cycles. These cycles are caused by the sockeye maturing predominately at 4 years of age.

INDEX OF ABUNDANCE FROM TRAPS

The salmon traps form a very reliable means of determining the abundance of the sockeye, inasmuch as they were driven year after year in the same location; and, although the fishing ability of the individual trap may have varied somewhat from year to year, on account of weather or tides, yet the decrease in the catch of one trap is apt to be compensated for by the increase in another if a sufficiently large sample is utilized.

In making this index traps were selected from various localities so as to discount the effect of any slight changes in migration routes or any diminution of the numbers migrating past any one locality, which might be caused by hydrographic conditions or by sockeyes of different lake systems using different migration routes through the salt water channels leading to the mouth of the river. Of the 43 traps selected, 3 were from the Point Roberts Area, 12 from Boundary Bay, 5 from Birch Bay, 4 from Lummi Island, 6 from Rosario Strait, 3 from the South Lopez Area, 4 from Salmon Banks, 1 from Waldron Island Area, and 5 from Haro Strait. No trap selected fished less than 10 years and 5 of them fished from 1898 to 1934, or 37 years, without a single break. They averaged 27 fishing years each between 1896 and 1934. The use of more traps would have given too much weight to the Boundary Bay Area which was already well represented. In most of the other areas all available traps were used to aid in compensating for changes in the route followed. No traps were used from West Beach as they also catch sockeyes bound for the Skagit River, but, as this area is a small producer of sockeyes, its omission can be of no consequence in determining the trend.

As not all of these traps fished every year during the period under consideration, it was necessary to determine the relative efficiency of each trap, especially since no two traps are exactly alike in their potential capacity to catch fish. In determining these efficiencies it was, of course, necessary to use a base.

The use of any one year as a base could not give a very accurate picture of their relative efficiencies, so a 28-year period was employed, from 1902–31; with the exception of 1908 and 1922. Fifteen traps were found that had fished every year during this period, of which 1 was from the Point Roberts Area, 10 from Boundary Bay, 2 from Birch Bay and 1 each from the Lummi Island and Salmon Bank Areas. For these traps an average annual catch per trap was computed. Using these average annual catches as a standard, or base, the proportion that the total annual catches of each of the 43 traps formed of the same annual catches of the standard was found. Instead of using these proportions as weights, each trap was assigned an efficiency weighting which was the calculated average annual catch it theoretically would have caught had it fished for the whole 28 years represented by the standard, or base, curve. This was done for each trap by merely multiplying the average annual catch of the standard curve for the 28 years by the above-mentioned proportion.

Having determined the relative efficiency of each of the 43 traps, the index was made by dividing for each year the total catch of such of the 43 traps as were driven by the total efficiency weightings of the same traps. The index figures are not actual numbers of fish but, as with most other indices, are to be considered in relation to one another. However, they give roughly the percentage that each year's catches are of the average of the 28 years represented in the standard curve.

Even though the trend of the base curve for the 15 traps rose or fell at a different rate than did the trend of the traps as a whole, this method of determining the efficiencies would prevent this difference in the trend from having any effect on the final index unless a large share of the traps selected fished for only a short number of years at one end of the period of time. Since this condition does not obtain, the index is believed to be a reliable measure of the changes that have occurred in the trap catches.

TABLE 32.—*Sockeye index of abundance from traps, 1896–1934*

Year	Catches	Efficiency weights	Number of traps	Index of abundance	Index from standard curve	Year	Catches	Efficiency weights	Number of traps	Index of abundance	Index from standard curve
1896	259, 512	157, 152	6	165. 134	--------	1917	1, 777, 158	1, 361, 590	43	130. 521	139. 225
1897	843, 303	349, 089	10	241. 572	--------	1918	350, 451	1, 316, 830	39	26. 613	23. 548
1898	821, 677	381, 254	11	215, 520	--------	1919	306. 114	1, 161, 984	35	26. 344	29. 226
1899	2, 663, 376	755, 475	21	352. 543	--------	1920	499, 406	932, 553	27	53. 553	52. 306
1900	942, 721	868, 394	26	108. 559	--------	1921	621, 190	1, 310, 431	42	47. 403	47. 050
1901	5, 095, 464	833, 241	26	611. 523	--------	1922	328, 554	802, 564	20	40. 938	--------
1902	1, 403. 869	983, 037	30	142. 809	132. 035	1923	276, 658	1, 180, 625	36	23. 433	24. 950
1903	703. 336	983. 037	30	71. 547	70. 728	1924	555, 636	972, 745	27	57. 120	65. 769
1904	609, 681	912, 297	25	66. 829	68. 660	1925	679, 459	1, 302, 442	38	52. 168	59. 422
1905	4, 273, 212	1, 033. 479	31	413. 478	424. 986	1926	272, 170	1, 171, 431	33	23. 234	24. 999
1906	875, 782	990, 361	29	88. 431	90. 637	1927	392, 468	1, 263, 574	39	31. 060	36. 742
1907	512. 369	976, 475	28	52. 471	53. 652	1928	418, 199	1, 121, 823	32	37. 279	35. 085
1908	907, 670	824, 243	23	110. 122	--------	1929	552, 836	1, 310, 431	42	42. 187	47. 686
1909	4, 621, 094	1, 095, 853	31	421. 689	406. 717	1930	629, 889	1, 195, 611	36	52. 683	48. 720
1910	1, 058, 917	1, 042, 569	28	101. 568	98. 828	1931	298, 260	1, 169, 332	36	25, 507	23. 957
1911	657, 770	1, 232, 865	33	53. 353	56. 610	1932	338, 576	743, 919	21	45. 513	--------
1912	1. 082. 917	1, 198, 760	32	90. 336	86. 775	1933	753, 311	1, 115, 144	32	67. 553	--------
1913	5, 790, 820	1, 226, 629	35	472. 092	492. 264	1934	921, 829	1, 076, 915	33	85. 599	--------
1914	1, 282, 777	1, 294, 252	35	99. 113	96. 928						
1915	244, 628	1, 342, 578	40	18. 221	20. 320	Total	45, 110, 330	----------	--------	----------	--------
1916	487, 271	1, 106, 225	33	44. 048	42. 167						

The index would appear to be extremely reliable for trap-caught sockeyes, as, during the period from 1896–1934 the 43 traps caught 45 million sockeyes while the total trap catch since the beginning of the fishery totals but 94 million. During the past 20 years, when complete figures for trap catches are available, our sample comprised as high as 82 percent of the trap catch in 1924, and fell only as low as 54 percent, in 1915 and 1917.

The index (table 32 and fig. 24) shows a marked decline in abundance in all four age cycles, comparing favorably with the average catch per unit of gill net effort, except in a few years. In 1897 the abundance shown by the trap index is decidedly lower than that shown by the gill net averages, but a large part of this discrepancy may be due to the fact that a great many of the traps were driven for the first time in 1897 and so had not yet been efficiently located. The details of the levels of abundance shown will be discussed under the various cycles.

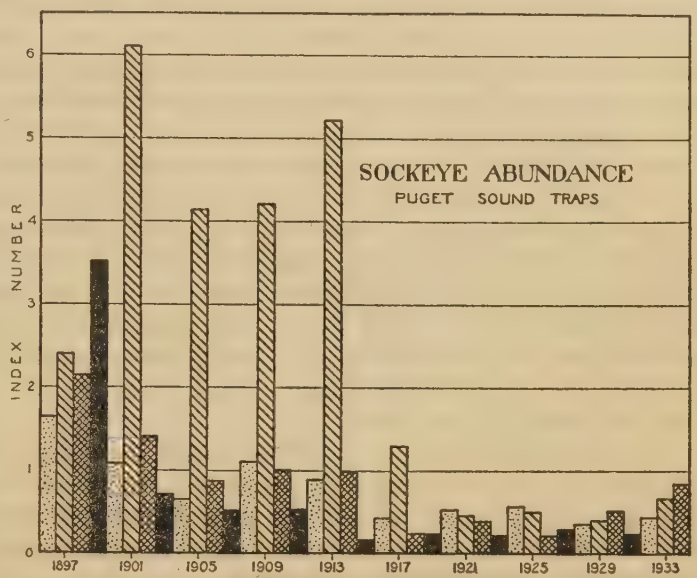


FIGURE 24.—Sockeye index of abundance calculated from the catches of Puget Sound traps for the 39-year period from 1896–1934. A decrease in abundance has occurred in all cycles.

PURSE SEINES

In the 26 years since 1909 when purse seines became an important factor in the sockeye fishery, their catch has exceeded that of the traps in only 3 years: 1930, 1931, and 1934. Their success in 1930 was due to the heavy schooling, especially at Point Roberts, of the abundant late run which, massed in the shallows off the river mouth, were easily seined. The 1931 catch exceeded that of the traps because the seines had their second most successful season on Swiftsure Bank. In 1934 the purse seiners were prepared for a repetition of the abundant late run of 1930 and, although they did not do as well in the inside waters, they caught over three times as many sockeyes on Swiftsure Bank as in any previous season. In 7 of the 26 years their catch in both inside and offshore waters totaled less than 150,000 sockeyes per year. Six of these were even-numbered years when no pink salmon were running. The seiners fished during the early season for cohos in the offshore waters, and during the late season for both cohos and chums in the inside waters.

In the odd-numbered years, which have abundant pink salmon runs, usually three or four times as many sockeyes are seined as in even years, because there are more seine boats fishing, and they are largely concentrated during the late summer in the areas where the pink salmon are migrating on their way to the Fraser River and other streams in the Gulf of Georgia.

The average size of the purse-seine delivery is not a good measure of sockeye abundance. In the even-numbered years it tends to be high, as the boats fish only during the height of the run. In the odd-numbered years it tends to be low, as the boats often made a large number of catches, containing few sockeye per catch, while fishing primarily for pink salmon. The purse seine catches are thus not as reliable as a measure as either the trap or gill-net catches, but they do show how the purse seines have fared under varying conditions of abundance.

In making this index the number of sockeye taken each year during each 7-day period was divided by the weighted number of deliveries. The weights were given according to the size of the boats making the catches in accordance with the efficiency weighting for all species described in the purse seine section of this report. Data were available for every year, except 1920, from 1911–34. Of the 23 years remaining, the data for 1918 cover such a short period of time that they were not used in computing a normal curve for each week From the other 22 years a normal average daily delivery was made for each of the 6 weeks between July 15 and August 25, by merely dividing the sum of the averages for all years by the number of years. No week had less than 19 years data.

For each year the sum of all the average daily deliveries for the six 7-day periods between July 15 and August 25, or as many of these six periods as there were data for, was divided by the sum of the average daily deliveries for the same periods for the normal. The resulting index then is a measure of the annual abundance expressed as a percentage of the normal.

The purse-seine index of abundance differs from the trap index in a number of years, but before deciding on the meaning of these differences several factors must be considered. Thus the actual catch of sockeye in 1918, 1922, 1924, 1926, and 1928 by purse seines in Puget Sound was less than 100,000 fish. In 1918 it was only 45,000 and in 1928 it was but 62,000. In such years the total quantities caught by purse seines were very low in relation to the actual abundances.

In certain other years the purse-seine index is very high in relation to that for traps, as the purse seines may make catches out of all proportion to the abundance when the fish are heavily concentrated, as they were at Point Roberts in 1930. Although it has seemed unwise to lay any stress on the purse-seine index as an accurate measure of abundance, yet, considered in relation to the trap and gill-net indices, it portrays the fluctuations in availability of sockeyes to the purse seines, and is thus necessary to an understanding of the fishery.

TABLE 33.—*Sockeye index of abundance from Puget Sound purse seines, 1911–34*

Year	Number of fish	Number of catches	Weighted number of catches	Average size of delivery for week ending—				
				July 14	July 21	July 28	Aug. 4	Aug. 11
1911	25,634	262	238.52		55.92	138.72	178.85	134.93
1912	80,955	442	452.16	29.24	53.54	180.21	201.96	286.11
1913	1,312,188	799	904.26	39.48	196.42	555.81	1,999.39	2,938.88
1914	405,937	1,176	1,308.00	35.81	87.31	230.62	555.60	261.75
1915	60,644	1,815	2,184.32		9.12	30.27	40.35	40.13
1916	36,645	513	590.52	15.99	55.15	71.77	65.22	55.73
1917	180,477	890	1,181.70	22.36	88.20	243.28	460.00	120.46
1918	7,708	153	192.20		47.63	36.31	40.15	42.20
1919	22,229	212	311.22				72.20	138.27
1920								
1921	59,340	1,174	1,668.70		81.19	72.67	53.17	38.89
1922	19,954	149	137.54			46.06	69.78	113.51
1923	80,279	1,253	1,780.62			12.83	32.36	32.87
1924	26,253	184	247.76		52.23	160.78	131.59	113.68
1925	61,764	837	1,220.70	17.24	99.59	115.38	87.20	40.41
1926	74,904	504	666.34		18.09	62.57	115.05	194.10
1927	257,741	1,714	2,483.58		12.30	16.74	21.47	53.06
1928	54,603	1,212	1,755.96		45.21	54.44	45.58	34.65
1929	349,740	4,031	5,958.18	33.88	78.01	89.51	73.98	102.54
1930	1,503,026	2,451	3,921.71		10.55	31.52	82.94	76.52
1931	235,864	4,206	6,516.87	10.15	16.82	35.72	38.12	74.45
1932	364,018	3,711	5,832.54	24.15	26.50	55.70	102.86	74.97
1933	495,126	7,368	11,375.44	34.39	49.88	58.09	72.40	97.41
1934	1,227,634	2,758	4,222.36	18.60	21.74	33.36	50.02	164.51
Sum [1]	6,942,663	37,814			1,057.77	2,296.05	4,550.09	5,187.83
Number of years					19	21	22	22
Normal average					55.67	109.34	206.82	235.81

Year	Average size of delivery for week ending—Continued				Sum of weekly averages July 15 to Aug. 25	Sum of normal averages for same weeks	Index
	Aug. 18	Aug. 25	Sept. 1	Sept. 8			
1911	73.55	53.83			635.80	905.79	70.19
1912	97.43				819.25	787.13	104.08
1913	2,119.56	468.27	274.85	128.86	8,278.33	905.79	913.93
1914	24.04	111.30			1,270.62	905.79	140.28
1915	21.98	30.51	16.20	6.56	172.36	905.79	19.03
1916	36.82				284.69	787.13	36.17
1917	93.31	40.29	28.05	9.50	1,045.54	905.79	115.43
1918					166.29	607.64	27.37
1919	106.18	73.33	35.25	29.34	389.98	740.78	52.64
1920							
1921	32.88	23.03	8.70	6.36	301.83	905.79	33.32
1922	144.11	133.17			506.63	850.12	59.60
1923	67.44	65.02	42.79	13.96	210.52	850.12	24.76
1924	48.07				506.35	787.13	64.33
1925	44.22	32.16	21.22	18.37	418.96	905.79	46.25
1926	114.32	51.09			555.22	905.79	61.30
1927	54.07	125.09	147.26	152.07	282.73	905.79	31.21
1928	24.73	10.26	4.56	1.37	214.87	905.79	23.72
1929	90.01	50.41	27.74	9.01	484.46	905.79	53.48
1930	147.00	413.27	603.17	673.61	761.80	905.79	84.10
1931	56.95	33.90	26.77	13.78	255.96	905.79	28.26
1932	65.59	24.41	19.31	21.72	350.03	905.79	38.64
1933	56.09	27.75	17.94	9.15	361.62	905.79	39.92
1934	430.36	487.49	296.52	690.08	1,187.48	905.79	131.10
Sum [1]	3,948.71	2,254.58					
Number of years	22	19					
Normal average	179.49	118.66					

[1] Excluding 1918.

COMBINED INDEX OF ABUNDANCE

In years when fishing conditions favored the traps the gill net measure of abundance was usually lower owing to the toll exacted by the traps, but when conditions were reversed, as in 1915 and in 1926, the gill net index was the higher. Since the two measures are thus somewhat interdependent, neither one gives as clear a picture of the actual abundance as the two considered together. Therefore, the two have been combined.

In making the combination each index was, from 1896 to 1934, expressed each year as a percentage of its average over the whole 39-year period. In each year each percentage was then weighted in accordance with the percentage of the combined trap and gill net-caught sockeyes that had been taken by that form of gear. The weighted percentages were then combined to form the final index, which is given by 4-year cycles in table 34.

EXPLANATION OF CHANGES IN ABUNDANCE

Having reviewed briefly some of the causes of changes in the sockeye fishery, the question arises as to the present state of the fishery and the present state of abundance. In order to arrive at any reasonable conclusions account must be taken of the changes that have occurred within each cycle of 4 years—four years, as mentioned above, is the age at which the majority of the Fraser River sockeye mature—in regard to the size of the spawning escapements, and the extent of the areas seeded.

TABLE 34.—*Abundance by cycles of Fraser River sockeyes*

Year	Combined index of abundance	Year	Combined index of abundance	Year	Combined index of abundance	Year	Combined index of abundance
		1896	134.1	1897	411.7	1898	132.4
1899	236.0	1900	69.4	1901	421.4	1902	126.4
1903	72.6	1904	48.3	1905	374.7	1906	96.4
1907	40.2	1908	78.8	1909	299.3	1910	89.2
1911	46.5	1912	79.1	1913	377.5	1914	80.8
1915	33.4	1916	29.3	1917	90.1	1918	19.0
1919	23.3	1920	39.9	1921	35.6	1922	35.4
1923	24.5	1924	43.7	1925	42.6	1926	70.3
1927	43.2	1928	28.1	1929	39.8	1930	59.3
1931	29.6	1932	45.9	1933	49.8	1934	75.6

The providing of a large number of spawners, while of importance, cannot achieve permanent rehabilitation unless these spawners are members of several different "races" or "colonies" of sockeye, so that they will migrate to many different lake systems. Such a distribution of spawners will insure ample spawning gravel for the adults, will guard the fishery against failure when on occasion unfavorable conditions of weather or enemies destroy the spawning of any single lake system, and will give a greater stability to the fishery as it is far better to have successive waves of migrating adults passing through the gear, than to have the whole season's migration occur in a very few weeks, as may easily happen when the total migration is to one lake system. A clearer conception of these waves of migration may be gained by thinking of the main river merely as an extension of the salt water channels up which different races of fish migrate to their spawning grounds on several independent lake systems. The principal lake systems of the Fraser River, the tributaries of which are sockeye spawning grounds, are shown in figure 25.

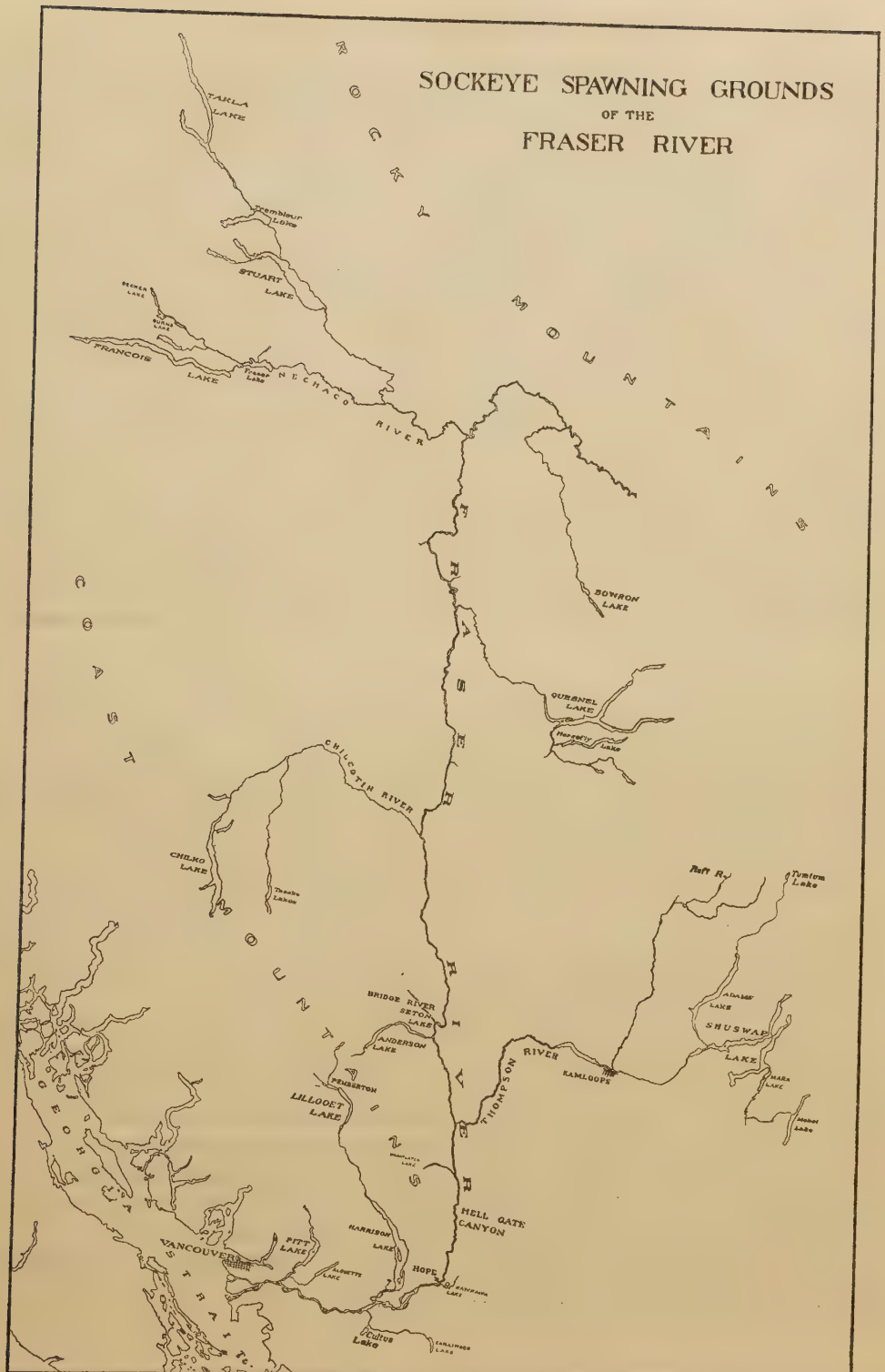


FIGURE 25.—Sockeye spawning ground of the Fraser River. All of the lakes shown are mentioned as sockeye lakes either in the reports of the British Columbia Commissioner of Fisheries or in the reports of the Department of Fisheries of Canada. Other lakes in this river system have been omitted. The sockeye spawn chiefly in the streams tributary to these lakes. The sockeye fry descend into these lakes and spend some time there, usually about a year and a half, before migrating to the sea.

Abundance of Cycle Ending in 1934

The cycle of years—1934, 1930, 1926, etc.—immediately following the big years showed a decline from 1898–1914 amounting to 39 percent from the 1898 level. The catch of 5,000,000 sockeyes in 1898 did not appear to be unduly heavy at the then existing level of abundance, only a 4 percent drop, which may not be statistically significant, occurring between 1898 and 1902. In 1902, however, the catch was increased to over 7,000,000 fish, resulting in a drop of 23 percent in the abundance of the 1906 run. Catches of over 4,000,000 in 1906 and 1910 were both too heavy for these lower levels of abundance and the catch continued to decline.

In 1914, the lowest level of abundance the cycle had thus far experienced, the fishing was very intense. One hundred traps fished in the sockeye areas, the most in any off year since 1903, and the gill net effort was exceeded only by 1900, 1901, and 1903, resulting in a catch of 5,700,000 sockeyes. The spawning ground reports for 1914 indicated the poorest escapement on record, which was amply borne out by the run of 1918, the next year of this cycle, which was the poorest in the whole history of the Fraser River fishery.

The intensive fishery of 1914 was doubtless instrumental in causing this remarkably low escapement, but there is little doubt that at least a small portion of the blame must be laid on the blockade of Hell's Gate in 1914. The report on this blockade stated that no salmon were able to ascend through the canyon from August 10 to 25, and that the fish had great difficulty in passing at other times, some 20,000 being put over the rapids with dipnets.

Although a fair amount of gear was employed in 1918 the catch of just over 800,000 was relatively much less than that of 1914, considering the very low level of abundance. However, the remarkable increase in abundance between 1918 and 1922 cannot be explained in terms of catch or escapement. The survival rate of the sockeyes being influenced to a great extent by conditions in the lakes, and probably, to a lesser extent, by conditions in the ocean, is subject to occasional violent fluctuations. In this case the result was a doubling in the level of abundance between 1918 and 1922.

In 1922, with the sockeyes much more numerous than in 1918, the catch was only slightly over 1,000,000 fish. The number of sockeye traps was the lowest since 1898 and the gill net effort had fallen considerably since the war years, permitting the best off year escapement for several years, possibly since 1912. One feature of the 1922 run was a fair escapement to the Shuswap-Adams Lake system.

The relatively good escapement of 1922 was reflected in an improved run in 1926. The run was exceptionally late, and, in addition, appeared not to have followed its usual migration routes through the salt-water channels leading to the mouth of the Fraser River. As a result, neither the traps nor the purse seines in Puget Sound caught many sockeyes, and the gill net operators on the Fraser River received the full benefit of the run, catching more per unit of fishing effort than in any year since 1913. However, the number of gill nets was so small that the escapement was relatively very high in proportion to the catch, which was slightly under 1,400,000.

The results of the 1926 escapement are shown in the catches of 4,600,000 and 5,000,000 in 1930 and 1934, respectively.

Abundance of Cycle Ending in 1933

The big year cycle, ending in 1933, 1929, 1925, etc., was tremendously abundant from the earliest records of the commercial fishery in 1877 up until the cycle following the Hell's Gate disaster of 1913. In earlier years the catch was so strictly limited by the capacity of the canneries that the index of abundance was always too low. All one can say is that the cycle was far more abundant than the others. In 1897 the trap index is considerably lower than in 1901, due largely to the fact that many of the traps were driven for the first time in 1897. That the big-year cycle was somewhat higher, as indicated by the combined index of abundance, in 1897 and in 1901 than in any of the succeeding years is undoubtedly true. In 1901, for instance, one trap in Boundary Bay caught 680,000 sockeyes between July 10 and August 29, which is as much as the entire trap catch of sockeyes for 11 out of the 21 years since 1913.

The 1901 catch of 25,800,000 sockeyes was, next to 1913, the largest in the history of the fishery. The trap catch in 1901, with less gear, was equal to that of 1913, and the gill net catch of 11,800,000 was 3,000,000 higher than that of 1913. In 1913 the power purse-seine fleet, which was nonexistent in 1901 (only hand-propelled seine boats were then in use), took 10,000,000 fish.

However, the difference in the catches of 1901 and 1913 was not due in any measure to a difference in the amount of gear, but rather to the great increase, by 1913, in the canning capacity of the plants. The number of sockeye wasted in 1913 was as nothing compared to the squandering of a natural resource that took place in 1897 and 1901. Rathbun (1899) says:

> The run of 1897 was one of the largest, if not the largest, in the history of the region. Preparations had been made in anticipation of a good year, both on the Fraser River and in Washington. The great body of sockeye first made its appearance about the middle of July and continued until about the end of the first week in August, a relatively short season, but during this period the cannery pack was completed and in addition an immense amount of fish was thrown away, the daily catch being often much larger than could be disposed of. It has, in fact, been claimed, though this is probably an exaggeration, that more fish were caught and wasted than were utilized.

Concerning the waste of sockeyes in 1901 the Report of the British Columbia Commissioner of Fisheries for 1909, page I 11, says:

> The catch that year (1901) was so great that every one of the canneries on both sides of the international line filled every can they had or could obtain; and in addition to the millions of fish which they packed that year, many millions more were captured, from both the Canadian and American waters of the Fraser River District, which could not be used, and were thrown back dead into the water. The waste of sockeye of our own catch and of that of the Americans in 1901 is believed to have been greater than the number caught and packed by all the canners on the waters mentioned in any year since, with the exception of 1905 and this year.

Despite catches averaging 24,700,000 sockeyes per year in the big years from 1901 to 1913, huge numbers escaped to the spawning grounds. The spawning ground surveys made by the Provincial Fisheries Department estimated millions in 1901 and 1905. In 1909 estimates made by counting, for a portion of each day, the number of sockeyes ascending the fishway at Quesnel Dam showed that over 4,000,000 fish entered the lake. The sockeyes were thicker in the Chilco River than the observer had ever seen them in any unobstructed stream. Fully 1,000,000 were estimated to have entered Seton and Anderson Lakes. Shuswap and Adams Lakes were better

seeded than in 1905, when most of the very heavy late run went to that lake system. The runs to Lillooet and Harrison Lakes, below Hell's Gate, were practically a failure.

The fact that tremendous numbers of sockeyes escaped to the spawning grounds on the big years, despite the huge catches, may have occurred because of the presence in all of the big-year cycles from 1901–13 of very abundant late runs, appearing after most of the fishing had ceased. The extent of this late run on the big years is indicated in the following quotation from the British Columbia Commissioner of Fisheries Report for 1909:

> On September 16, 1905, there appeared in the channels at the mouth of the Fraser a run of sockeye so numerous as to lead many competent observers to state that it equalled that which appeared during the first two weeks in August. This late run continued until the first week in October. None of these fish were observed in Juan de Fuca Strait, or in the American channels leading to the Gulf of Georgia and the Fraser River. During the first week of this movement several of our canners packed the fish, and a considerable number of them were purchased for and shipped to American canneries . . . Nothwithstanding the fact that there had been a similar run in the Fraser in September and October of 1901, the claim was made that the late run of 1905 was most unusual. The same claim was again advanced as to the late run this year (1909). It appears evident, however, from the numbers of sockeye which ran in the lower Fraser in September and October of 1901 and 1905, and again this year, that a late run is characteristic of the big years.

Whether the huge catch of 1913 had enough effect on the spawning escapement to have affected the abundance of the 1917 run will never be definitely known, as a portion of the sockeye ascending the Fraser River in 1913 were prevented from reaching the spawning grounds on account of rock slides, incidental to the construction of a railway at Hell's Gate in the canyon near Yale. The spawning-ground estimates of 1913 show 552,000 entering Quesnel Lake, contrasted to 4,000,000 in 1909, the previous year of the cycle. Chilco Lake was likewise estimated to have had about one-eighth as many as in 1909. Anderson and Seton Lakes had an estimated escapement of 30,000 against 1,000,000 in 1909. Lillooet and Harrison Lakes, below Hell's Gate, had poor runs. However, large numbers were seen in Adams River; and in Little River, connecting the outlet of Shuswap Lake with Little Shuswap Lake, the spawning sockeyes appeared as thick as in 1905 or 1909. The run at Stuart Lake was reported to be one-twentieth as large as on most big years, and that at Fraser Lake about 50 percent as large.

From the foregoing it is evident that, whether due chiefly to the obstruction at Hell's Gate, or to the tremendous catch, the spawning escapement of 1913 was considerably curtailed. In spite of this curtailment, the run of 1917 was of such size that, had the fishing effort been sufficiently reduced to allow an escapement even comparable to that of 1913, the big-year cycle might have continued to dominate. However, the total fishing effort was probably as great as in any of the preceding big years, a relatively large portion of the run being taken before it even reached the river, as is shown by the small gill-net catches.

Spawning-ground surveys in 1917 showed 26,000 spawners arriving at Quesnel Lake as against 552,000 in 1913. The Chilcotin Indians caught but 15,000 in the Chilcotin River compared with 25,000 in 1913. Seton Lake had not to exceed 200 fish caught by actual weir count. Shuswap and Adams Lakes had much less than in 1913. Harrison and Lillooet Lakes had the poorest spawning escapement that they had known.

The returns from this spawning brought a run in 1921 only two-fifths as abundant as that of the parent year. The catch of 1,700,000 in 1921 was relatively a great deal less, for the abundance level, than that of 6,800,000 in 1917. Since 1921 this cycle has been very slowly recuperating, increasing about 25 percent in abundance by 1933, according to the combined index. Besides producing the best pack of the last 4 years of this cycle, 1933 also had the best spawning escapement since 1917. Especially worthy of note was the good escapement to the headwater lakes as compared to other recent years. For instance, over 100,000 are estimated to have reached Chilco Lake. A fair number reached the lakes of the Stuart system. The escapement to the Fraser-Francois Lake system was twice that of 1929 and for the first time in years numbers of sockeyes reached Burns Lake.

Abundance of Cycle Ending in 1932

The cycle of years, 1932, 1928, 1924, etc., immediately preceding the big years was the poorest of the 4 throughout the early years of the fishery, and in common with the other off years, this cycle commenced to decline before the beginning of the century.

In 1900, while still at a fair level of abundance, this cycle was fished with extreme intensity, the gill-net effort being the highest in the whole history of the fishery and the number of sockeye traps as great as in the big year of 1901. The resulting catch of 4,400,000 was too great a proportion of the run, the abundance declining over 30 percent by 1904. In 1904 the fishing intensity was greatly reduced, only 2,400,000 sockeyes being taken, and the cycle recuperated. In 1908 the fishing intensity was again dropped, yet a larger catch of 2,700,000 was made.

The abundance in 1912 was apparently as great as in 1908, as is shown both by the combined index and by the catch of 3,400,000 which was made with slightly more traps and about the same gill-net effort as the catch of 2,700,000 in 1908. Furthermore, the proportion taken by the gill nets was much greater in 1912 than in 1908 which might indicate a better escapement. This is confirmed by spawning-ground estimates that would certainly place 1912 ahead of 1908.

The index of abundance fell 63 percent between 1912 and 1916. In 1916, although the number of traps was fairly low, the gill-net fishery was very intense, yet only 1,300,000 fish were taken, and the unusually small proportion taken by the large number of gill nets would indicate a small escapement. The estimates show that it was probably the smallest escapement in the history of the fishery.

Because the spawning of 1912 produced a run so very far below the average expectation for such a relatively good escapement, we are forced to conclude that the failure in 1916 was not caused by overfishing, but by some natural condition, possibly connected with spawning, that greatly reduced the rate of survival. It is impossible, at this date, to know what all of the spawning-ground conditions were, but we have noted that the early months of 1913, when the eggs would have been incubating in the gravels of the spawning beds, were extremely cold.

Average monthly temperatures from 1888–1930 at Barkerville and from 1891–1930 at Kamloops were studied. These two points were chosen for having long series of observations and for being close to the spawning grounds. For each locality the

average monthly temperatures for January, February, and March were added for each year, and the sum subtracted from the mean average of the sum of these 3 months for the whole series of years. The two series of temperature deviations were added for each year and divided by two (see table 35). It will be noted that in both series the winter of 1913 was the second coldest in 42 years. That this long protracted cold spell might well have had a deleterious effect on the success of the 1912 spawning is obvious, but the point cannot be pressed until information on the effect of severe cold upon spawning has been collected.

Although the escapement was reported as very poor in 1916, the abundance was somewhat higher in 1920, a much less intense fishery producing about the same catch as in 1916. The abundance was at practically the same level in 1924 as in 1920.

The cycle fell off slightly in 1928 but recovered in 1932 owing probably to the very small catch that was made in 1928 in proportion to the abundance.

TABLE 35.—*Winter temperatures of the upper Fraser River valley, 1888–1930*

Year	Barkerville		Kamloops		Average deviation in degrees	Year	Barkerville		Kamloops		Average deviation in degrees
	Sum of average temperatures, Jan., Feb., and Mar.	Deviation from average in degrees	Sum of average temperatures, Jan., Feb., and Mar.	Deviation from average in degrees			Sum of average temperatures, Jan., Feb., and Mar.	Deviation from average in degrees	Sum of average temperatures, Jan., Feb., and Mar.	Deviation from average in degrees	
1888	70.0	+8.9				1912	63.1	+2.0	82.0	−5.6	−1.80
1889	72.4	+11.3				1913	43.7	−17.4	63.8	−23.8	−20.60
1890	64.1	+3.0				1914	63.7	+2.6	94.9	+7.3	+4.95
1891	53.8	−7.3	86.9	−0.7	−4.00	1915	77.2	+16.1	105.3	+17.7	+16.90
1892	65.0	+3.9	94.3	+6.7	+5.30	1916	35.4	−25.7	65.5	−22.1	−23.90
1893	55.1	−6.0	73.2	−14.4	−10.20	1917	49.0	−12.1	70.1	−17.5	−14.80
1894	60.7	−.4				1918	63.4	+2.3	89.2	+1.6	+1.95
1895	66.8	+5.7				1919	59.3	−1.8	91.1	+3.5	+.85
1896	58.9	−2.2	95.0	+7.4	+2.60	1920	63.4	+2.3	89.9	+2.3	+2.30
1897	56.4	−4.7	83.5	−4.1	−4.40	1921	64.2	+3.1	96.3	+8.7	+5.90
1898	68.8	+7.7	91.7	+4.1	+5.90	1922	46.5	−14.6	69.3	−18.3	−16.45
1899	53.1	−8.0	80.8	−6.8	−7.40	1923	59.1	−2.0	84.4	−3.2	−2.60
1900	74.5	+13.4	103.5	+15.9	+14.65	1924	71.8	+10.7	99.4	+11.8	+11.25
1901	63.4	+2.3	91.1	+3.5	+2.90	1925	65.8	+4.7	93.0	+5.4	+5.05
1902	68.8	+7.7	100.8	+13.2	+10.45	1926	85.0	+23.9	111.0	+23.4	+23.65
1903	60.6	−.5	84.7	−2.9	−1.70	1927	58.0	−3.1	89.0	+1.4	−.85
1904	49.6	−11.5	81.0	−6.6	−9.05	1928	73.0	+11.9	96.0	+8.4	+10.15
1905	68.8	+7.7	97.7	+10.1	+8.90	1929	52.0	−9.1	71.0	−16.6	−12.85
1906	70.1	+9.0	101.2	+13.6	+11.30	1930	49.0	−12.1	76.0	−11.6	−11.85
1907											
1908	61.7	+0.6	88.9	+1.3	+.95	Sum	2,565.1		3,241.6		
1909	49.1	−12.0	82.2	−5.4	−8.70						
1910	60.6	−.5	94.7	+7.1	+3.30	Number of years	42		37		
1911	50.2	−10.9	73.2	−14.4	−12.65	Average	61.1		87.6		

ABUNDANCE OF CYCLE ENDING IN 1931

The cycle of years containing 1931—1931, 1927, 1923, etc.—has been the least abundant since 1899. The gill-net index shows that for six consecutive cycles, up to and including 1899, it was more abundant than the cycle following it. In 3 of the 6 years, 1887, 1895, and 1899, it was also more abundant than the cycle preceding it. Between 1899 and 1903 this cycle fell 69 percent according to the combined index of abundance—the largest drop in abundance in recent years with the exception of that of the big-year cycle after 1913.

In 1899 both the trap and gill-net fisheries, especially the latter, were quite intense, resulting in a catch of 11,400,000 sockeyes. This catch does not appear to be excessive in relation to the index of abundance when compared to the catches of the big years. On the other hand, there is a possibility that the escapement in 1899 (no surveys were made of the spawning grounds) was much less than the mere comparison of the catch with the level of abundance would indicate, as neither the trap nor the gill-net data point to any late run in 1899, although the evidence is not conclusive. This same cycle had a late run in 1887, mentioned in the Dominion Report for that year, which states that many sockeyes were caught as late as October, which was very unusual. In all of the big-year cycles, from 1901–1913, very abundant late runs appeared after most of the fishing had ceased and provided heavy escapements. Since there is no evidence of a late run in 1899, it is quite possible that the catch was too heavy to allow a sufficient escapement.

Some have ascribed this fall in abundance to the blocking of the Quesnel River by a dam at the outlet of Quesnel Lake, built in 1898, which caused the majority of the sockeyes reaching the dam to die below it without spawning, until after the construction of a fishway in 1904. That some of the sockeyes could not ascend the race is quite possible but that the majority did not enter the lake would seem to be refuted by the run of several millions that passed into the lake in 1905. If none spawned there in 1901, the run of 1905 cannot reasonably be accounted for.

The dam and fishway are thoroughly described in the British Columbia Commissioner's Report for 1904. The dam was 18 feet high and the race was 124 feet wide and 382 feet long, with a drop of only 6 inches. At the head of the race there were 9 gates, each 12 feet wide. At the time of the sockeye run the water in the race was said to average 4 or 5 feet in depth, with a velocity of 12–14 feet per second. The fishway was merely a walled-in section along one side of the race. It was 26 feet wide and every 25 feet timbers 2 feet high were placed on the bottom to form an inverted V pointing upstream. The fishway led to two of the gates, one of which was kept open during the sockeye run.

The dam was constructed for the purpose of shutting off the waters of Quesnel Lake in the fall of the year in order that mining operations could be carried on in the bed of the Quesnel River. Obviously the lake was permitted to become as low as possible during the summer so that the gates were merely openings through which the lake water flowed into the race.

In 1905 the wall separating the fishway proper from the race was washed out, but the fish continued to ascend, and a low wall was substituted for the former high one. It is obvious that the problem was not passage through the gates but merely that of getting the sockeyes through the race. There would appear to be little doubt but that the majority of the sockeyes passed this obstruction. That a matter of some thousands could not, should be regarded as of no greater moment than the residue that fail to negotiate any fall or rapid of any consequence in a natural stream.

Since the first great decline in this cycle, between 1899 and 1903, there has been a further decrease. From 72.6 in 1903 the combined index fell to 40.2 in 1907, due, as before, to overfishing. Remembering the good pack of 1899, large preparations were made in 1903, resulting in a catch of 4,300,000. The traps were numerous and the number of gill nets was exceeded only in 1900 and 1901. It is not surprising

therefore that so large a catch was made at so low a level of abundance, or that the abundance had declined an additional 47 percent by 1907.

In 1907 only three-quarters as many traps and one-half as many gill nets were employed as in 1903. The catch of 1,700,000 doubtless permitted a larger escapement than in 1903. This is reflected by a slightly increased abundance in 1911. In 1911 the number of traps remained about the same as in 1907 and the gill-net intensity was slightly lower, yet the yield was larger, being 2,200,000.

According to the combined index of abundance there was a fall of 39 percent between 1911 and 1915, but this figure is undoubtedly too large. The trap index for 1915 was the lowest of the whole 39 years, but that it was so low chiefly on account of the failure of the run to pass by the traps is shown by the gill-net catch. This was nearly twice that of 1911, or about what one would have expected if the number of sockeyes reaching the gill nets in 1915 had been somewhat comparable to the number reaching them in 1911, as the gill-net fishing effort was about twice that in 1911. Since the number removed by the traps before reaching the gill nets was much greater in 1911 than in 1915 it is probably true that the 1915 level of abundance was slightly lower than that of 1911.

Between 1915 and 1919 the abundance declined another 30 percent, according to the combined index, and probably more if the 1915 level were higher than shown. The spawning ground reports claim that in 1915 fewer sockeyes passed through Hell's Gate to the spawning grounds of the upper Fraser than in any year since observations were started in 1901. On the other hand, the number spawning in the tributaries below the canyon, Lillooet Lake, Harrison Lake, Cultus Lake, Pitt Lake, etc., was estimated as being the largest for some years, even including 1913. Because of the failure of the traps to take many sockeyes, the total catch of 1915 was but 1,800,000.

Considering the catch of 1915 in relation to the abundance, it does not appear to have been sufficiently large to have been the sole cause of the drop in 1919. Rather, it would appear that the extremely cold weather early in 1916, when the eggs deposited in 1915 were incubating (see table 35), had some part in it. The temperatures prevailing early in 1916 were even colder than in 1913. The reason for this second instance not showing as great a fall in abundance as in the first instance, when the temperatures were not quite as low, probably lies in the fact that in 1912 by far the larger portion of the spawning escapement went to the lakes above Hell's Gate, in 1915 most of the spawning was below Hell's Gate where it would not be affected by the cold temperatures of the upper Fraser.

This is borne out by the 1919 escapement estimates, which for the region below the canyon were as high as in 1915, whereas practically none were found above the canyon. The survey was more thorough than usual and the dearth of up-river fish was very marked.

In 1923 the abundance level was about on a par with 1919. There were only two-thirds as many traps and slightly fewer gill nets than in 1919, resulting in a catch of 850,000 compared to 1,250,000 in 1919. Since 1919 was able to bring back a comparable run in 1923 with a larger catch it is not surprising that 1927 showed a much improved condition.

In 1927 both the trap- and gill-net fisheries were slightly more intense than in 1923. The purse seine boats were also more numerous. The net result was a catch of 1,800,000 in 1927 against 850,000 in 1923, and, as might be expected, the level of abundance fell off somewhat in 1931.

COHO SALMON

By George B. Kelez

INTRODUCTION

Ascending almost every stream and river of the region on their spawning migrations, cohos are the most widely distributed salmon present in these waters. Although suffering a severe decrease in numbers in recent years, they have formed a considerable portion of the catch throughout the history of the salmon fishery.

This species provided the bulk of the pack of the first Puget Sound cannery and of the establishments which immediately succeeded it in that district. They formed the major portion of the catch of the natives resident at Neah Bay when fishery operators first visited that region in quest of new supplies of salmon. The catches of the early type of purse seines were composed almost entirely of cohos, and they have provided the chief source of the seiner's income in off years up to the present time. This species is also the principal salt-water catch of summer vacationists and recreational fishermen throughout the region.

The first coho catches of the season are made during the early summer by the troll and purse-seine fleets operating in the waters off Cape Flattery, and on Swiftsure Bank. Great schools of immature fish feed there at that time, and large catches are common for a period of several weeks. In late summer the adult cohos begin their migration through the inner waters of the region to the tributary rivers where they will spawn, and the major part of the commercial catch is made during the period of this migration by traps, seines, and gill nets.

LIFE HISTORY

SPAWNING

The majority of the mature fish enter fresh water during the months of October and November, although some may run as early as September, and a few individuals may tarry in salt water until the latter part of January. Actual spawning usually begins a week or two after the fish first enter the streams, and often extends throughout the winter months. Some of the salmon hatcheries in the region have continued to strip eggs up to the middle of March, but most of the natural spawning has terminated before that date. In general, late spawning is confined to the smaller, shorter streams.

Active and highly adaptive to different conditions, coho salmon may spawn on suitable gravel beds only a few miles from salt water, or may ascend the larger rivers to tributary streams in the mountains which surround the region. Such variations in time and locality of spawning cause considerable differences in the time of hatching of the eggs and in the growth of the fry.

GROWTH

The time of hatching of the eggs depends on temperature conditions, but usually occurs during the early spring. The greater part of the young fish remain in the streams throughout the summer and the following winter, and usually migrate to salt water early in their second year.

Growth in fresh water is quite rapid, especially in the streams of southern Puget Sound where temperatures are favorable and food is plentiful. In these streams the fry usually have attained a length of approximately 30 mm by early March, whereas those in the more northerly part of the region may not reach this size until the latter part of May. By September the size range of the southern fingerlings is from 60–70 mm. Collections of fish in their second year, taken in early March, show a size range of from 80–95 mm. By early May these fingerlings measure from 100–130 mm.

During spring and early summer the fingerlings migrate from the upper reaches of the rivers to the estuaries, and finally into salt water. Scale collections from these populations indicate that the majority of the fingerlings migrate to salt water during the early spring freshets, but that many remain in the streams for a much longer period of time.

After reaching the inner waters of the region, young cohoes may be found in large schools for a period of several weeks. At this time they have reached a size of from 14–20 cm. The greater part of these young fish gradually migrate to the waters of the Pacific Ocean. Clemens (1935) states that tagging experiments have indicated that some of the cohoes never leave the Strait of Georgia. Sport-fishing catches in the lower sound confirm the presence of cohoes there throughout all stages of their life in salt water.

These fish remain in salt water during the second winter of their life, and throughout the following summer, during which time they experience a remarkable increase in size. Gilbert (1913) reported the cohoes at the cape to average 13.35 fish per case on July 23 and 7.56 fish per case on September 2. Smith (1921) stated that the average weight of cohoes taken by trollers in the same region increased from 5.63 pounds on July 8 to 9.75 pounds on September 2. Recent samples from the commercial catches taken in the inside waters of Puget Sound during October indicate a size range from 5.13–14.90 pounds, and an average weight of 9.47 pounds at this time. Individual fish of more than 20 pounds in weight have been taken by sport fishermen in this region.

Some indications of the migrations of cohoes in inside waters are given by tagging experiments reviewed by Clemens (1930). Recoveries were made of forty-seven immature cohoes tagged in 1927 at Deep Bay, in the northern part of the Gulf of Georgia. Of these, 29 were recovered north of the point of tagging, or on the lower coast of Vancouver Island, 3 were recovered in the Fraser River, and 1 in the nearby Capilano River. Approximately 30 percent were recovered in Puget Sound, some being taken as far south as Whidbey Island.

From a similar experiment at Nanaimo in 1928, 163 recoveries were made. Of these, 34 were taken north of Nanaimo and 34 in the general vicinity of the tagging, 43 were taken in the Fraser River and vicinity, 8 were taken in the Strait of Juan de Fuca, or west of it, while 44, approximately 27 percent, were taken in Puget Sound.

Of these latter recoveries, 15 were in the vicinity of Whidbey Island and in the Skagit River. These results would indicate that some individuals of the southern runs must either remain in the Gulf of Georgia during their life in salt water, or migrate inside of Vancouver Island on their return from the sea to the streams where they will spawn.

AGE AT MATURITY

Pritchard (1936) reported that commercially caught fish, secured for tagging experiments along the British Columbia coast during the years 1927–31, ranged in age from 2 to 4 years, but that 97.89 percent of these fish were in their third year.

A small number of grilse, almost entirely precocious males, returned to the streams in the fall of their second year. Fraser (1920) reported that, of 2,000 cohoes examined from the Gulf of Georgia in 1916, all but 28 were in their third year, and that these 28 fish were all males in their second year. Gilbert (1912) reported a very few "sea-type" scales, from fish which have descended to salt water during their first summer, in his collections from Puget Sound. Pritchard reported 0.35 percent of this type of scale in his collections.

It is reasonable to expect considerable fluctuations in the size of the runs of any species of which a high proportion of the individual fish mature at the same age. For those salmon which descend to salt water shortly after hatching, a considerable spawning escapement, combined with favorable conditions on the spawning grounds, often results in an extremely high return at maturity of that particular brood.

That coho salmon, which mature almost entirely at 3 years of age, have not experienced any sudden increase in numbers may be largely due to the fact that they have a long stream residence during their early life history. Because the carrying capacity of streams is physically limited, and there exists a considerable competition between the young stream-dwelling salmon and resident trout or other species, the numbers of fingerlings surviving until they begin their seaward migration cannot be increased beyond a certain point, even in very favorable years. Although this factor has doubtless had considerable influence in preventing large increases in numbers of coho salmon, the existence of so many populations in various streams has conversely aided in averting any sudden decrease in abundance, hence fluctuations in the numbers of this species have never been violent.

INDIVIDUALITY OF POPULATIONS

That the populations of different streams tend to be individual in nature is supported by some experimental evidence. Gilbert (1913) reported the return in the fall of 1911 at Scotts Creek, California, of several coho salmon grilse from fingerlings marked there during the preceeding winter; no data as to returns of mature fish from this experiment were published. Fraser (1921) reported the recovery in Cowichan Bay, on October 11, 1917, of 1 coho salmon from 1,000 fry marked at the Cowichan Lake hatchery in March 1915. Pritchard (1936) reported the recovery in 1927 of 19 adult cohos in Cultus Lake, B. C., from 72 fish marked there during the spring of the same year. These fish were in the early part of their third year when marked. and returned as adults after having remained only a few months in the sea.

During the spring of 1934, 26,000 coho fingerlings, averaging 47.4 mm in length, which were made available through the cooperation of the Washington State Department of Fisheries, were marked by the author at Friday Creek, a tributary of the Samish River. During the same month, 9,800 coho fingerlings, averaging 49.2 mm in length, were transferred from the Skykomish River and were marked and liberated in Friday Creek. In November of that year an additional 26,000 fingerlings from the same brood as the fish used in the first experiment were also marked and liberated at Friday Creek. This lot averaged 101.6 mm in length at the time of marking. Complete data on returns to the Samish River of six grilse from the third marking experiment were obtained during the spawning run of 1935, and the capture of two additional marked grilse was reported from a reliable source.

The run of normally maturing three-year-olds appeared during the winter of 1936–37, and 480 marked fish were recovered from the Samish River, 7 from the first experiment, 11 from the second, and 462 from the third. No recoveries have been made from nearby streams or from the Skykomish River. From these results it would appear that mortality is much higher for the smaller fish, and that there is a definite tendency for mature cohos to return to spawn in the stream from which they migrated to the sea.

LOCALITY OF CAPTURE BY DIFFERENT TYPES OF GEAR

CATCHES IN VARIOUS DISTRICTS

Cohos have been second in demand only to kings for consumption as fresh fish, and large quantities have always been used in local markets. Because of their suitability for freezing they have surpassed all other species as a supply for the considerable demand of cold-storage units which have maintained an active market since the earliest years of the present century. For these reasons the canned-pack figures for this species are an unreliable measure of the commercial catch in past years. Although they have been the mainstay of the cape purse-seine fishery throughout its history, Gilbert (1913) reporting over 850,000 cohos taken there as early as 1911, and have formed the major part of the offshore catch of trollers, no records of the high-seas catches have been kept for other than very recent years.

It is impossible without thorough tagging experiments to determine the proportion of the cape catch provided by the populations of the Puget Sound-Fraser River region. Because of their widespread range of operation, part of the troller's catch landed in Washington may well be drawn from other sources. The purse seiners, however, are usually concentrated in the area off the entrance to the Strait of Juan de Fuca, and their catch doubtless consists mainly of the populations from the region. We may infer, from the far greater size of the runs entering the Strait of Juan de Fuca than of those conceivably passing the Banks en route for any other nearby district, that the major portion of the catch there is drawn from the regional populations.

In Puget Sound the trap fishery usually suspended operations in early years before the coho run had begun, except in the inside waters where the catch consisted

mainly of this species. However, from the time that the fishing season of the northern traps was increased to include the fall runs up to the last decade, traps took the major part of the cohos caught in Puget Sound waters. In late years purse seines have become the chief source of this species.

The major part of gill-net catches in the estuaries of such rivers as the Skagit and the Snohomish have been coho salmon. Although considerable catches of coho salmon have been made on the Fraser River, especially in years when sockeye were not abundant, fall fishing has never been prosecuted as strenuously in that district as in the Puget Sound region.

Except for recent years data are not available for catches other than in a portion of the region, hence it is not possible to present complete figures for coho salmon production prior to 1926. During this latter period the catch has been considerably smaller than in previous years. The total catch of coho salmon for Swiftsure Bank, Puget Sound, and the Fraser River, by various types of gear from 1926–34, is presented in table 36.

LOCALITY OF TRAP CATCHES

Because of the mobile nature of the purse-seine fleet, the determination of the particular district of the region in which their catches were made is not possible from past records. The best indication of the coho production of specific localities may be had from a consideration of the catches of the traps located therein. The total catches of traps in restricted areas are presented for the period from 1896–1934 in table 37.

Most of the areas in this table may be readily located from figures 2 and 3. "Lower sound" includes the water south of Useless Bay on Whidbey Island. "Miscellaneous" includes such inner bays as Bellingham, Padilla, and Samish, as well as Possession Sound and Hood Canal, but four-fifths of these fish were from the waters south of Point Wilson.

TABLE 36.—*Catch of coho salmon, 1926–34*

Year	Fraser River catch [1]	Puget Sound traps	Purse seines		Trollers		Puget Sound gill nets	Minor Puget Sound gear	Total, all gear
			Puget Sound	High seas	Puget Sound	High seas			
1926	120,663	384,600	232,721	375,000	22,269	325,000	57,436	6,266	1,523,955
1927	226,710	536,937	354,976	188,750	23,491	400,000	108,360	5,051	1,844,275
1928	203,580	436,819	236,085	195,844	18,538	339,311	65,092	4,163	1,499,432
1929	334,467	397,381	319,847	432,095	19,331	329,026	61,757	8,655	1,902,559
1930	71,280	285,310	204,692	407,405	15,589	355,040	65,228	4,125	1,408,669
1931	79,254	241,873	449,081	225,798	6,655	267,916	40,527	1,099	1,312,203
1932	160,452	102,727	331,565	315,290	3,457	281,686	22,240	1,262	1,218,679
1933	125,883	244,755	248,686	174,728	4,922	176,529	35,421	2,194	1,013,118
1934	113,382	164,504	233,418	365,380	12,709	261,804	40,038	507	1,191,742
Total	1,435,671	2,794,906	2,611,071	2,680,290	126,961	2,736,312	496,099	33,322	12,914,632

[1] Converted from cases at 9 fish per case, does not include cohos caught elsewhere in the Gulf of Georgia and canned on the Fraser River, or Fraser River cohos used for purposes other than canning.

TABLE 37.—*Annual catch of coho salmon by traps, in different areas, 1896–1934* [1]

Year	Area												Total
	Point Roberts and Boundary Bay	Sandy Point to Boundary Bay	Lummi Island and Rosario Strait	Haro Strait and Waldron Island	Salmon Banks and South Lopez	Hope Island and Skagit Bay	West Beach	West of Point Wilson	Admiralty Inlet	Lower Sound	Miscellaneous	Unidentified	
1896	1,632						13,062					265	14,959
1897	2,170		31,000				54,361						87,531
1898	61,753						26,628						88,381
1899	1,270	27,938	42,107	1,607	32,832		25,587	15,459	43,329	9,621	13,163	1,034	213,947
1900	20,095	22,375	6,893	20,909	46,204	38,378	13,499		152,757			4,048	325,158
1901	3,181	19,913	22,171	33,588	52,919	41,600	24,405		211,079		29,846	13,340	452,042
1902	1,020	2,185	19,576	24,811	52,756	39,710	18,566		142,348				300,972
1903	5,540	6,570	3,841	5,476	27,486		15,272					65	64,250
1904	751	655	409	49,113	16		9,544		127,130				187,618
1905	7,708	8,457	8,622	10,696	29,087	28,181	27,432		221,547				341,730
1906	9,296	16,093	10,421	66,102	23,065	27,818	45,012		266,710		878		465,395
1907	33,559	15,135	14,919		38,533	33,952	51,321		234,528		16,047		437,994
1908	18,096	12,835	18,496	49,020	14,446	27,065	43,073		165,302				348,333
1909	226	51,504	61,876	155	70,061	42,785	52,952		258,668				538,227
1910	62,782	65,523	82,728		64,552	35,329	37,215	31,894	148,860		11,467	32,052	572,402
1911	49,647	107,906	105,140	690	46,124	54,815	64,693	83,830	254,102		20,148	60	787,155
1912	64,851	52,223	54,671	12,529	35,583	7,768	47,249	55,274	190,532		38,064		558,744
1913	7,808	35,299	42,682	1,134	3,871	1,659	18,802	36,590	143,723		10,584	11,080	313,232
1914	18,355	21,169	49,846	6,611	9,711	34,963	31,881	13,398	64,539		24,629		275,102
1915	67,608	45,389	64,972	60,516	16,642	38,730	51,921	27,289	205,632	10,500	32,061	20,621	641,881
1916	36,093	27,046	38,741	30,035	21,317	52,355	39,015	9,163	118,047	14,914	31,332	6,792	424,850
1917	80,524	38,972	37,671	40,062	19,278	34,634	31,106	12,761	117,263	5,310	40,132	4,190	461,903
1918	85,164	64,159	100,167	40,382	66,632	46,614	46,467	10,190	173,963	22,752	51,516	1,635	709,641
1919	86,545	52,551	62,028	42,307	46,442	61,023	50,982	15,796	184,763	15,517	23,617	443	642,014
1920	31,581	5,214	20,693	7,759	14,970	22,457	20,845	1,667	99,898	16,465	17,534	1,500	260,583
1921	31,550	11,213	25,821	24,308	9,548	44,639	14,553	3,295	103,691	22,741	7,338	192	298,889
1922	53,589	22,400	69,311	16,857	9,407	99,331	17,377	9,612	105,081	27,083	35,498		466,046
1923	48,621	24,171	50,049	22,478	10,502	49,884	21,680	4,059	186,609	11,400	16,169		445,622
1924	63,090	27,432	46,974	18,290	20,142		36,097	6,171	203,304	64,422	19,215		505,137
1925	60,440	25,616	32,738	17,231	15,301	41,222	13,452	13,825	186,083	6,041	11,865		423,814
1926	55,973	16,808	33,617	17,993	12,172	30,144	16,232	37,683	134,455	19,619	11,672	21	386,389
1927	76,058	34,756	47,234	17,772	19,334	59,197	31,764	21,895	211,748	16,981			536,739
1928	75,948	43,134	48,130	9,270	22,203	19,470	23,469	17,382	130,361	12,527	6,034		407,928
1929	66,880	32,631	56,387	10,574	11,814	28,431	21,198	12,536	129,908	13,579	9,289	524	393,751
1930	19,047	9,549	20,581	6,708	5,372	49,278	27,784	11,896	102,317	21,844	8,464		282,840
1931	28,247	31,146	23,354	6,165	4,594	32,895	17,883	10,256	72,879	6,948	14,939		249,306
1932	2,693	3,199	12,374	2,015	3,717	22,652	2,869	6,390	36,107	6,992	3,490		102,498
1933	15,845	14,874	17,421	6,411	14,908	16,292	14,590	23,829	108,676		12,837	5	245,688
1934	15,170	3,184	22,162	3,710	6,508	16,380	8,442	8,354	47,019	11,677	8,729		151,335
Total	1,370,406	999,224	1,405,823	683,284	898,049	1,180,151	1,128,280	500,494	5,282,958	336,933	526,557	97,867	14,410,026

[1] Incomplete before 1915.

Out of a total catch in all areas of nearly 14½ million fish, approximately 4½ million were taken in the northern part of the region, 2½ million in areas through which the populations of both northern and southern districts migrate, and more than 7 million in the southern areas of the region. Of the latter total, more than 5¼ million fish were taken from Admiralty Inlet alone.

SEASONAL OCCURRENCE IN VARIOUS AREAS

The general seasonal occurrence of coho salmon from different types of fishing gear has already been presented. However, as might be anticipated in the case of migrations of populations from widely scattered streams, occurrence varies considerably in different districts. These variations do not seem to be correlated with the distances which the fish must travel along their migration routes, but appear to depend largely upon the characteristics of the individual populations. Because the traps sample individual runs in exact localities, their catches were used as the best measure of seasonal occurrence in various portions of the inner waters of the region.

Data were available from 26 traps which fished throughout the duration of the coho run in most of the years from 1911–34. Districts selected (see figs. 2 and 3) and number of traps were as follows: Point Roberts 2, Boundary Bay 4, Birch Bay 5, Rosario Strait 4, Dungeness Spit and Middle Point 3, Admiralty Bay 3, Bush Point 3, and Hope Island 2. The total number of fish included in the catches of these traps was 5,652,592. From these data the average proportions of the season's catch taken in each 7-day period by the traps in various districts were calculated. These figures are presented in table 38. Because of the essential similarity in occurrence, Point Roberts and Boundary Bay have been grouped, as have Admiralty Bay and Bush Point.

TABLE 38.—*Seasonal occurrence of coho salmon from traps; proportion of total catch taken in each 7-day period*

Week ending—	Area										
	Point Roberts	Boundary Bay	Point Roberts and Boundary Bay	Birch Bay	Rosario Strait	Dungeness Spit and Middle Point	Admiralty Bay	Bush Point	Admiralty Bay and Bush Point	Hope Island	All districts
May 5						0.062	0.002	0.056	0.044		0.018
May 12					0.090	.038	.202	.024	.056		.035
May 19	0.822		0.871	0.046	.124	.105	.216	.034	.071		.059
May 26	.554		.588	.024	.100	.077	.138	.041	.073		.054
June 2	.496		.526	.327	.077	.068	.157	.072	.107		.084
June 9	.265		.281	.348	.073	.070	.131	.069	.094		.080
June 16	.148	0.162	.154	.297	.121	.072	.224	.103	.151		.103
June 23	.143	3.703	1.207	.396	.114	.086	.494	.158	.298		.175
June 30	.461	1.058	.627	.343	.132	.127	.494	.132	.302	0.001	.174
July 7	.277	.649	.414	.695	.174	.261	1.273	.227	.757	.003	.351
July 14	.207	1.944	.937	.676	.370	.451	.867	.447	.667	.003	.393
July 21	.526	1.460	.946	.940	.636	1.214	.730	.465	.601	.057	.466
July 28	.451	1.610	1.001	1.210	.784	1.781	.599	.565	.583	.031	.532
Aug. 4	1.053	1.358	1.171	1.367	1.127	2.600	.613	.745	.681	.421	.769
Aug. 11	.518	1.464	.962	1.810	1.484	3.684	.796	.817	.808	1.825	.962
Aug. 18	.517	1.512	.985	1.880	1.915	3.563	1.269	1.540	1.412	3.178	1.413
Aug. 25	2.018	2.373	2.132	2.997	3.998	4.938	2.853	2.809	2.829	4.457	2.717
Sept. 1	5.068	5.117	4.950	6.393	6.091	7.840	3.732	4.026	3.891	5.366	3.911
Sept. 8	11.926	6.476	9.020	7.805	10.671	8.335	6.955	6.191	6.495	7.853	6.953
Sept. 15	12.540	14.586	13.173	13.341	13.462	7.360	10.041	9.459	9.689	10.329	10.795
Sept. 22	15.238	16.145	15.262	10.382	13.845	11.857	13.724	13.382	13.485	14.373	12.652
Sept. 29	15.194	11.935	13.513	9.271	11.967	12.869	13.004	13.411	13.200	12.789	12.129
Oct. 6	9.737	8.276	9.127	9.126	9.950	11.686	14.033	14.038	13.991	14.159	12.628
Oct. 13	8.501	9.454	8.819	10.385	10.211	10.076	12.091	12.479	12.279	12.351	11.978
Oct. 20	4.209	7.579	5.221	9.648	6.339	4.894	6.894	9.025	8.091	6.629	8.357
Oct. 27	6.042	2.681	5.315	7.727	4.149	4.041	3.897	4.862	4.441	2.993	5.313
Nov. 3	2.631	.459	2.314	1.756	1.553	1.845	2.256	2.290	2.270	1.362	3.108
Nov. 10	.457		.484	.810	.441		1.262	.939	1.061	.914	1.628
Nov. 17							1.053	1.000	1.000	.546	1.502
Nov. 24								.547	.528	.301	.667
Dec. 1								.044	.043	.008	.051
Dec. 8								.003	.003		.005
Total	99.999	100.001	100.000	100.000	99.998	100.000	100.000	100.000	100.001	99.999	100.002

Comparing the data for the Point Roberts-Boundary Bay area with those for Birch Bay, occurrence in both areas is slight until the latter part of August, when the runs increase abruptly in size. The run at Point Roberts and Boundary Bay increases steadily to a peak in the week ending September 22, and abundance decreases materially thereafter, with minor fluctuations, to the end of the season. Birch Bay clearly shows the presence of the same run as that of the former area, but occurrence is distinctly bimodal. The peak of the main run occurs in the week ending September 15, after which there is a definite decrease in numbers. A second run of smaller proportions follows, reaching its peak between October 6 and October 20, the run falling

off abruptly thereafter. The main portions of the runs of both areas are probably contributed by the Fraser and other northern rivers, but the second peak in the Birch Bay area may be composed largely of populations of such rivers as the Nicomekl and the Serpentine.

A comparison of the data for the Point Roberts-Boundary Bay area with those from Rosario Strait indicate that the run in the latter area corresponds closely with that of the more northern districts; the somewhat earlier appearance here is probably due to the lesser distance of migration from the sea. There is a strong indication that a large part of the runs passing through Rosario Strait continues to Boundary Bay without entering Birch Bay. The Rosario Strait data are shown graphically in the lower section of figure 26.

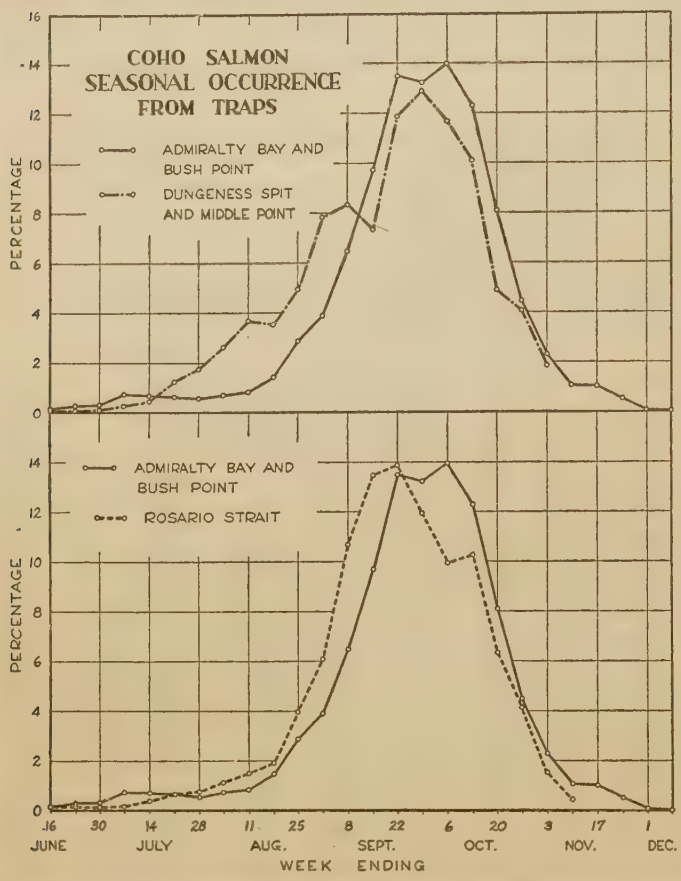


FIGURE 26.—Seasonal occurrence of coho salmon in trap catches from the southern part of Puget Sound. In the lower section of the figure occurrence in the principal southern area is compared with that of one of the northern areas.

A comparison of seasonal occurrence of the Dungeness Spit-Middle Point area with that of the Admiralty Bay-Bush Point area indicates that the early appearance of cohos in the former area is consonant with its more seaward location. In this area a relatively heavy run follows the first group of fish, appearing during late August and early September, after which the intensity slackens. This is followed by the main run, which reaches its peak in the last week in September and drops abruptly after the second week in October. It is evident that traps in this area fish a mixed population, but that the main run consists of fish bound for the southern areas.

The Admiralty Bay-Bush Point run increases steadily from the last week in August to the third week in September, remains at a high level for three more weeks, and decreases steadily thereafter to the middle of November. Unlike the other areas, the run does not terminate here, but continues at a low level until early December. The data for seasonal occurrence in these areas is presented graphically for comparison in the upper section of figure 26.

In the lower section of figure 26, occurrence in the Rosario Strait area is compared with that of the Admiralty Bay-Bush Point area. Although both of these areas are immediately adjacent to waters in which their individual runs mingle, seasonal occurrence of cohos in Rosario Strait is considerably earlier than in the southern area, in fact the run in the former area has begun to decrease almost at the time that the southern run has first reached its peak. The Admiralty Bay-Bush Point runs also show a more prolonged peak of occurrence, and continue much later in the season.

From table 38 it is evident that the Hope Island run is almost identical in occurrence with that of the Admiralty Bay-Bush Point area, although the small catches in the early and late portions of the season appear only in the latter area. It is apparent that a large proportion of the Skagit River runs must pass around the southern end of Whidbey Island in the course of their migration.

CHANGES IN ABUNDANCE

CALCULATION OF TRAP INDICES

It is apparent, from both trap and purse-seine catches, that there has been a considerable diminution in abundance of cohos in recent years. Inasmuch as traps and purse seines have been the principal types of gear catching coho salmon in this region, trends of abundance were determined from catches by both types of gear, and are presented together for comparison.

In measuring abundance from traps, several difficulties are encountered which arise from the lateness of the coho runs in relation to those of other species taken by this type of gear. During early years, in certain areas where other species formed the principal catch, the traps were often removed from the water after fishing during only part of the coho season. Closed periods, which were imposed through legislation in many of the years after 1920, also prevented the traps in certain areas from fishing during the entire coho run. Years in which these closures were enforced cannot be compared directly to those in which fishing was not restricted unless some provision is made to offset the shorter fishing period. In most early years the traps were permitted to fish well into the winter months, while in later years legislation has often terminated the season before the entire run has appeared. For these reasons it was impossible to use the catches of any trap unless the opening and closing dates of its annual fishing seasons were known. This requirement sharply curtailed the available amount of data.

In order to make the annual catch data comparable for both early and late years, they were weighted according to the length of the period fished. Inasmuch as the coho runs in the various districts are quite uniform in time from year to year, the average seasonal occurrences already presented were used as a basis for determining the time period of the runs in their respective districts.

November 10 was arbitrarily selected as the end of the fishing season. The catches of traps which fished later in the year were reduced in proportion to the percentage occurrence of the run after that date, and catches of traps which ceased

fishing before that date were similarly increased. For 1921, and for other late years in which closed periods have been in force, trap catches were increased by the average percentage occurrence during the closed periods in their respective areas. Catches of traps which fished for a lesser period of time than that in which 75 percent of the run for their district normally occurred were not included in the analysis.

A certain amount of error is unavoidably introduced by empirically increasing or decreasing catches for particular years to compensate for irregular length of fishing season. However, catches which were decreased in size were confined almost entirely to early years when fishing was less restricted, and nearly all increases in catches were made in later years when closed periods were imposed and fishing seasons were shortened by legislative action. Such error as may have accompanied these necessary corrections would tend to reduce the apparent level of abundance in early years and to increase it in later years. Any decline shown in the trend of abundance would thus be given added validity.

Three particular districts were selected for analysis. The first was that extending from Sandy Point to the international boundary, and included the Birch Bay, Boundary Bay, and Point Roberts areas (see fig. 2). Because of the size of the district and the large number of traps situated therein, catches were used from all traps for which suitable data were available. Prior to 1910 the data were meager, for sockeyes were of such importance in this region that catches of other species were often not recorded. After the tremendous sockeye run of 1913 most of the traps were removed before the coho run. In 1932, unfavorable economic conditions sharply reduced the number of traps fishing. During the remaining years, suitable data for from 7–12 traps were available. These traps, although but a small part of the total number fishing in the area, represent a considerable portion of those which were fished late enough in the season to intercept the coho migration. The number of traps available in this area, and their total catch for each year, are tabulated in the first two columns of table 39.

The second area selected was Rosario Strait. Although the runs in this district are largely composed of the same populations which pass through the northern areas, fishing conditions differ considerably, for the area of water through which the runs must pass is much more restricted and the number of traps is very small. Three of these traps, located in strategic positions, have taken the bulk of the catch in this area. Data for the 16-year period, from 1919–34, when at least two of these traps fished every year, all three of them for fifteen years, are tabulated in the third and fourth columns of table 39. It is evident that the efficiency of Rosario Strait traps is greater than that of those in the northern area, and their index of abundance should provide a useful check on that calculated from the larger group.

TABLE 39.—*Indices of abundance of coho salmon from traps*

Year	Data by areas						Index figures		
	North of Sandy Point		Rosario Strait		Admiralty Inlet		North of Sandy Point	Rosario Strait	Admiralty Inlet
	Number of fish	Number of traps	Number of fish	Number of traps	Number of fish	Number of traps			
1900					122, 723	2			2. 166
1901					201, 962	2			3. 544
1902					113, 063	2			2. 071
1903									
1904					140, 004	2			2. 558
1905	26, 353	2			195, 469	4	4. 409		1. 80¢
1906	33, 066	3			248, 189	4	3. 923		2. 03¢
1907	50, 087	6			180, 145	4	3. 828		1. 46¢
1908	47, 856	5			165, 054	3	5. 431		1. 644
1909	31, 174	1	56, 871	2	294, 398	3	9. 888	8. 288	3. 195
1910	99. 579	10	64, 779	2	163, 185	4	4. 009	9. 238	1. 548
1911	54, 261	10	77, 585	3	277, 837	4	2. 278	7. 813	2. 472
1912	113, 122	12	56, 977	3	205, 888	4	4. 083	5. 798	1. 701
1913	36, 503	5	47, 753	3	159, 062	3	2. 598	4. 787	1. 449
1914	58, 640	10	32, 398	2	68, 166	3	2. 328	4. 551	. 718
1915	56, 881	12	30, 114	3	131, 229	4	1. 835	2. 988	. 992
1916	50, 375	10	25, 440	3	70, 722	4	2. 245	2. 507	. 517
1917	53, 562	12	23, 418	3	94, 769	4	1. 838	2. 403	. 754
1918	108, 710	12	69, 690	3	116, 083	5	3. 433	6. 812	. 811
1919	73, 488	12	44, 131	3	122, 723	5	2. 461	4. 473	. 862
1920	44, 597	10	21, 485	3	69, 010	4	1. 852	2. 199	. 731
1921	59, 820	12	14, 844	2	78, 967	3	2. 143	2. 330	1. 297
1922	86, 589	7	46, 791	2	61, 253	2	5. 332	6. 740	1. 715
1923	76, 529	12	32, 619	2	166, 608	6	2. 672	4. 950	1. 017
1924	92, 276	10	25, 802	2	166, 520	6	3. 978	3. 748	1. 044
1925	57, 501	12	21, 950	3	165, 477	5	1. 852	2. 191	1. 078
1926	49, 163	11	20, 396	3	99, 946	5	1. 898	2. 066	. 690
1927	56, 853	12	26, 584	2	186, 117	6	1. 879	3. 907	. 996
1928	51, 430	10	23, 784	2	104, 412	6	2. 009	3. 510	. 561
1929	63, 629	12	29, 402	2	115, 487	7	2. 291	4. 122	. 608
1930	26, 169	11	10, 108	2	81, 478	7	. 933	1. 434	. 443
1931	28, 659	11	13, 470	3	58, 381	4	1. 182	1. 381	. 722
1932	1, 184	3	19, 919	3	33, 155	2	. 175	1. 951	. 710
1933	23, 828	7	14, 026	3	106, 083	7	1. 342	1. 350	. 578
1934	21, 781	8	19, 317	3	54, 639	5	1. 151	1. 847	. 388
Total	1, 633, 665		869, 653		4, 618, 204				

The third area selected was Admiralty Inlet (see fig. 3). Here, as in Rosario Strait, the runs are concentrated while migrating through a restricted passage, and the effectiveness of most of the traps is correspondingly great. Catches of from two to seven traps were available each year from 1900–1934, with the exception of 1903. The number of traps, and their corresponding total catches by years, are tabulated in the fifth and sixth columns of table 39.

The calculation of index figures from these data is complicated by the fact that only a few traps in each district have fished continuously throughout this period of years. There is a wide variation in the fishing effectiveness of different traps, and any determination, such as the average annual catch per trap, must be affected considerably by the proportions of efficient and inefficient traps fishing each year. In order to minimize this variation it was necessary to weight the catches in such a manner that the relative annual change in the average catch of each trap might be measured irrespective of the actual sizes of the catches from which the average was derived. Such weighting was accomplished for each district by selecting a group of traps which had fished in the same years over a long period of time, and from which the relative effectiveness of all traps in that district might be measured. From the sums of the annual catches of these traps the average annual catches were calculated;

each of these was then determined as a proportion of the average annual catch of the base group. The average annual catch of any trap which fished for a lesser period of years than did the standard traps was determined as a proportion of the average of the total catches of the base group for the same years as those in which that particular trap fished.

The annual catches of the traps were then divided by the proportional weights of the same traps, and the average of the resultant figures for any 1 year is the index figure for that year. The index figures for the three areas, tabulated in the last three columns of table 39, are not directly comparable as they now appear, but measure only the degree of change from year to year in the individual areas. The relative changes in the different areas will be considered in conjunction with the index derived from purse-seine catches.

CALCULATION OF PURSE-SEINE INDEX

Inasmuch as a considerable portion of the coho salmon taken in Puget Sound waters have been caught by means of purse seines, a determination of changes in abundance of the species based on purse-seine data provides a valuable comparison with the indices from trap catches.

The purse-seine index is similar to those derived from traps in that it is a measure of relative variation, from year to year, in the average catch of a unit of fishing effort. However, its construction is materially different in that the total seasonal catches of individual vessels are unknown, hence the size of the average delivery was used as the unit of measurement instead of the annual catch.

In order to eliminate the influence of deliveries made by the vessels fishing for other species of salmon than coho, only such deliveries as were made between September 2 and October 20 were included. Data were also limited to vessels of more than 9 net tons and less than 40 net tons. This restriction excluded both the very small vessels, which were not regular purse seiners, and the largest vessels, which fished on Puget Sound only occasionally in the fall.

Since the average delivery of the small vessels operating in early years could not be compared directly to that of the large-sized, modern vessels, the catches necessarily were weighted to compensate for the changes in efficiency. In determining the weighted average delivery of the fleet, the vessels of 10–14 net tons were considered as unity, and the weighted number of deliveries of vessels in larger size-classes were the product of their actual number of deliveries and the vessel efficiency of that particular size-class, taken from table 15. For each year from 1911–34 the sum of the number of fish in the catches of all vessels in the fleet was divided by the weighted number of deliveries. The weighted average delivery figures represent the average catch in terms of one size-class of vessels, hence they are directly comparable throughout the series of years. These figures are presented in the last column in table 40. The other columns in the table show the same data broken down according to groupings of vessels of various sizes.

TABLE 40.—*Index of abundance of coho salmon from Puget Sound purse seines*

Year	Indices from individual size classes							
	10–14 net tons			15–24 net tons				
	Number of fish	Number of deliveries [1]	Average delivery	Number of fish	Number of deliveries	Average delivery	Weighted number of deliveries	Weighted average delivery
1911	5,760	65	88.62					
1912	214	8	26.75	11,169	93	120.10	110	101.54
1913	4,231	60	70.52	8,261	105	78.68	124	66.62
1914	18,784	146	128.66	29,015	255	113.78	303	84.16
1915	12,732	243	52.40	45,495	606	75.07	788	57.73
1916	8,940	266	33.61	26,218	410	63.95	533	49.19
1917	5,689	387	14.70	18,050	754	23.94	1,010	17.87
1918	27,552	266	103.58	58,685	459	127.85	620	94.65
1919	13,846	247	56.06	28,481	430	66.23	581	49.02
1920	2,188	66	33.15	13,808	146	94.58	196	70.45
1921	12,637	154	82.06	45,580	477	95.56	634	71.89
1922	7,999	132	60.60	35,216	326	108.02	434	81.14
1923	6,049	128	47.26	31,433	435	72.26	583	53.92
1924	4,643	80	58.04	23,038	305	75.53	400	57.60
1925	11,921	222	53.70	38,578	553	69.76	724	53.28
1926	3,406	122	27.92	34,477	498	69.23	647	53.29
1927	6,962	178	39.11	35,280	655	53.86	858	41.12
1928	8,174	242	33.78	70,146	1,046	67.06	1,360	51.58
1929	14,327	440	32.56	74,835	1,489	50.26	1,995	37.51
1930	6,275	135	46.48	25,781	542	47.57	726	35.51
1931	7,360	253	29.09	54,640	1,277	42.79	1,711	31.93
1932	8,255	157	52.58	58,166	1,072	54.26	1,447	40.20
1933	5,545	334	16.60	35,987	1,600	22.49	2,144	16.78
1934	4,486	240	18.69	36,357	1,069	34.01	1,421	25.59
Total	207,975	4,571		838,696	14,602		19,349	

Year	Indices from individual size classes					Index from grouped size classes		
	25–39 net tons							
	Number of fish	Number of deliveries	Average delivery	Weighted number of deliveries	Weighted average delivery	Number of fish	Number of weighted deliveries	Weighted average
1911	1,024	10	102.40	18	56.89	6,784	83	81.73
1912						11,383	118	96.47
1913	1,067	9	118.56	16	66.69	13,559	200	67.80
1914	530	8	66.25	15	35.33	48,329	464	104.16
1915	645	16	40.31	29	22.24	58,872	1,060	55.54
1916	1,345	12	112.08	22	61.14	36,503	821	44.46
1917	11,890	211	56.35	390	30.49	35,629	1,787	19.94
1918	14,677	110	133.43	204	71.95	100,914	1,090	92.58
1919	11,833	125	94.66	234	50.57	54,160	1,062	51.00
1920	11,312	78	145.03	144	78.56	27,308	406	67.26
1921	58,882	424	138.87	780	75.49	117,099	1,568	74.68
1922	40,542	176	230.35	326	124.36	83,757	892	93.90
1923	34 578	295	117.21	546	63.33	72,060	1,257	57.33
1924	16,208	103	157.36	192	84.42	43,889	672	65.31
1925	31,709	303	104.65	561	56.52	82,208	1,507	54.55
1926	60,582	532	113.88	984	61.57	98,465	1,753	56.17
1927	55,697	624	89.26	1,167	47.73	97,939	2,203	44.46
1928	97,386	1,239	78.60	2,305	42.25	175,706	3,907	44.97
1929	91,493	1,486	61.57	2,779	32.92	180,655	5,214	34.65
1930	53,597	781	68.63	1,460	36.71	85,653	2,321	36.90
1931	95,752	1,760	54.40	3,326	28.79	157,752	5,290	29.82
1932	153,377	1,619	94.74	3,060	50.12	219,798	4,664	47.13
1933	66,264	1 974	33.57	3,731	17.77	107,796	6,209	17.36
1934	65,169	1,047	62.24	1,968	33.11	106,012	3,629	29.21
Total	975,559	12,942		24,257		2,022,230	48,177	

[1] Number of deliveries and weighted number of deliveries identical for this group, as efficiency weighting is unity.

TRENDS OF ABUNDANCE

The indices from traps and seines represent the relative availability of coho salmon to the particular type of gear and for the particular area in which that gear operated. The trap indices are for three individual areas, whereas the purse-seine index is necessarily based on catches made throughout the entire Puget Sound region.

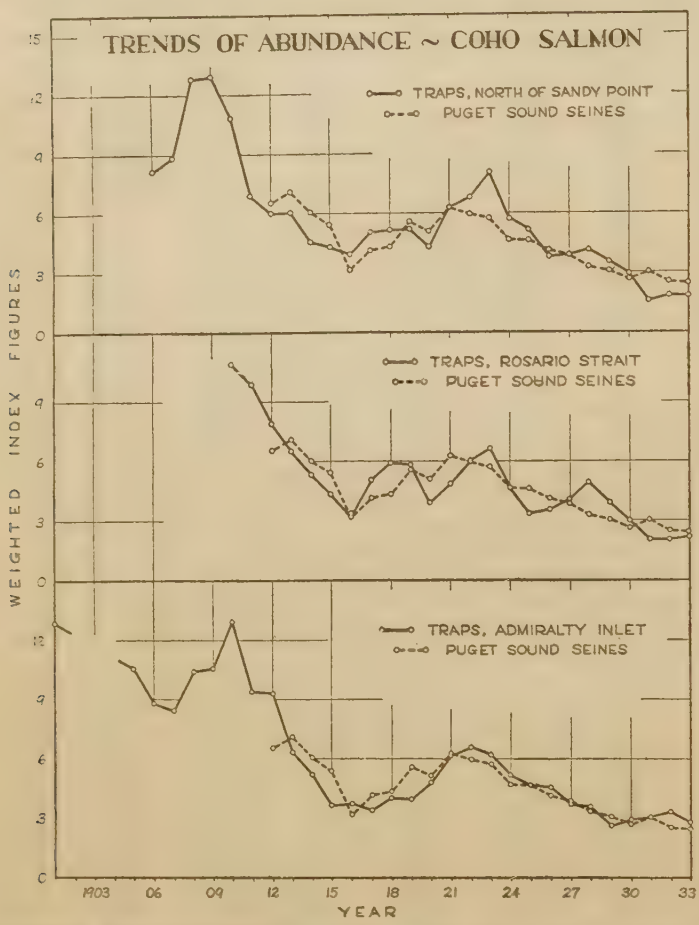


FIGURE 27.—Trends of abundance of coho salmon. Indices calculated from trap catches in three different areas are compared to the index calculated from purse-seine catches taken from the entire Puget Sound region. A considerable decrease in abundance has taken place since the early years of the fishery.

In order to show more clearly the trend of abundance of the species, the indices were smoothed once by threes. Since some 98 percent of these fish mature at 3 years of age, such smoothing also minimizes the effect of any predominate age-cycle. To facilitate comparison of the curves, it was necessary to reduce the indices to the same general range of variation, therefore each curve was proportionally reduced or increased so that the sum of the index figures for the years 1912–33 equalled 100.00. These smoothed indices are shown graphically in figure 27.

In the three sections of the figure the indices from traps north of Sandy Point, from Rosario Strait, and from Admiralty Inlet are compared with the seine index. The same general trend is apparent in all the indices.

A general high level of abundance is indicated prior to 1910, but the continued increase thereafter in numbers of all types of gear was accompanied by a decrease in abundance of the species. During the post-war depression, the considerable decrease in fishing effort throughout the region resulted in a general rise in abundance; this increase was quickly terminated, however, when fishing once more became profitable and the trend of abundance has declined from that point.

The indices correspond fairly well throughout, and since the post-war years the seine index is very similar to that for Admiralty Inlet traps. This is a direct corollary of the more intense purse-seine fishery in the southern district during these years,

throughout which this area has been the heaviest producer of coho salmon. It is further evident from these curves that the general level of abundance throughout the region has been lower in recent years than at any previous time in the history of the fishery.

That changes in the intensity of the fishery have exerted a considerable influence on the abundance of cohos has been indicated. However, abundance has been further affected by changing conditions in the streams where the adult fish spawn and the young are reared. Lumbering has been, or is now being carried on in the drainage basins of almost every river in the southern part of the region, and most of the cut-over lands have been cleared for agricultural purposes. Rapidity of run-offs and resultant flood conditions have become increasingly prevalent on these streams, many former spawning grounds have been rendered useless, and the carrying capacity of the streams for young fish during their stream residence has been reduced. Utilization of streams for water power or for industrial purposes has had a similar effect. There is a further possibility of the withdrawal of spawning grounds due to the impounding of waters in the upper reaches of these rivers for the purpose of controlling floods and erosion.

It is difficult to determine how far the level of abundance can decline before the populations of some areas pass the point at which they are able to rehabilitate themselves, even under the most stringent protection that legislation might offer. In view of these conditions it appears highly probable that the decline in numbers of this species will be continued unless there is a drastic change in the factors influencing their abundance.

KING SALMON

By George B. Kelez

INTRODUCTION

Populations of king salmon are found in most of the important salmon streams in the region, the heaviest runs usually appearing in the larger rivers. Averaging more than 20 pounds in weight, the kings are the largest of the 5 species of Pacific salmon. Their large size and high quality have always commanded the highest individual price of any of the species, and the greater portion of the catch has been absorbed by the fresh-fish markets or used for mild curing.

Kings from the troll fishery of Cape Flattery appear in the city markets in early spring and they are taken in gill nets throughout the fall months, but the bulk of the commercial landings are made in late spring and summer. Except in the gill-net catches in the rivers, both immature and mature fish appear together in the landings during the greater part of the fishing season. Sport fishing for kings, which has been popular with residents of the region for nearly 50 years, is carried on from April to September.

LIFE HISTORY

Possibly because of their greater size and strength, kings usually spawn in deeper, faster water than do the other species of salmon. Although the spring runs may ascend to small head-water streams, the later runs often spawn in the larger tributaries or even in the main channels of the rivers. There is a recognizable difference in the

time at which these runs enter the rivers; the races which spawn far upstream usually appear during the spring months, whereas the lower-spawning races do not appear until later in the summer or in early fall.

Gilbert (1913) and Fraser (1917 et seq.) both found that the greater part of the fry descend to salt water shortly after hatching, and a lesser proportion remain in the stream throughout the first winter and migrate seaward during the following spring. These findings were based on scale readings. Scales from fish which migrated to the sea as fry showed a typical rapid growth in the nucleus, those which migrated as yearlings showed a distinctly different nucleus, due to the less rapid growth in the stream. Fraser reported the proportions of these types in lower Gulf of Georgia fish to be 65.4 percent sea-type and 34.6 percent stream-type. His collections from the upper part of the Gulf of Georgia contained 78.2 percent of the former type and 21.8 percent of the latter.

Rich (1925) stated that in the Columbia River runs the stream-type nuclei indicated spring-running fish which spawned in the headwater streams, whereas sea-type nuclei predominated later in the season when the lower-spawning races of fish were entering the river.

After migrating to salt water, the young kings are frequently caught in the inner waters of the region before reaching the ocean. At this time they are called "blackmouth" by the fishermen.

Tagging experiments reported by Canadian investigators, Williamson (1925, 1926), Mottley (1929), Williamson and Clemens (1932), Clemens (1932), and Pritchard (1934), indicate that a considerable proportion of the young kings migrate northward and return along the coast of Southeastern Alaska and British Columbia on their migration to the streams where they will spawn. These experiments have also indicated the presence of large numbers of kings from the populations of other coastal rivers, both north and south of the region, in the same localities along the British Columbia coast. It is evident that a considerable mixture of populations occurs in the waters of the Pacific, and that catches of gear operating in the offshore waters may well contain large numbers of fish from streams other than those of the region.

Gilbert (1913) stated that kings taken in the commercial fishery of the region ranged in age from 3–7 years, and that the fish in their third year were grilse. Fraser (1921) reported that the commercial catch from the upper part of the Gulf of Georgia contained fish from 2–6 years of age, only part of which were mature. Of those individuals which had entered the sea shortly after hatching, nearly 50 percent were in their third, and approximately 35 percent were in their fourth year. The remainder were 2 and 5 years of age. Of those which had entered the sea after a considerable time in fresh water, some 30 percent were in their third year, 44 percent in their fourth year, 23 percent in their fifth year, and the remainder in their sixth year. The bulk of the mature fish were in their fourth and fifth years.

An important characteristic of the king salmon, unique to that species, is the considerable variation in the color of the flesh. Rathbun (1899) stated:

> While in some of the fish the flesh has its ordinary deep pink color, in others the flesh is white or only slightly tinged with pink. All intermediate gradations of colorations, as well as intermixtures of the two, occur, and no degree of this variation is distinguishable from the outside.

Cobb (1911) stated:

> In most places the flesh is of a deep salmon red, but in certain places, notably Southeast Alaska, Bristol Bay, Puget Sound, and British Columbia, many of the fish, the proportion being sometimes as much as one-third of the catch, have white flesh. No reasonable explanation of this phenomenon has yet been given.

Aside from color, the flesh of white and red kings taken at the same time in the fishery is of the same quality. This, together with the definite difference in proportion of white kings in various districts of the region throughout the season, which will be discussed later, indicates a strong possibility of a hereditary color-characteristic. The Fraser River king pack is canned as red, pink, and white kings. It is possible that a part of the late-season pack may consist of red kings whose color has faded with approaching sexual maturity. However, heavy catches of white kings are made by trollers off the west coast of Vancouver Island in late July and August, at which time the color cannot be ascribed to changes accompanying sexual development. Since these fish are not caught below Destruction Island, southwest of Cape Flattery, it is highly probable that they are part of the run which appears in the northern part of Puget Sound in September.

LOCALITY OF CAPTURE BY DIFFERENT TYPES OF GEAR

CATCHES IN VARIOUS DISTRICTS

The demands of the fresh-fish markets, and methods of processing other than canning, have absorbed the greater part of the catches of king salmon, hence the canned packs are of little use in determining the annual catch of the species. The catch on Puget Sound alone has averaged 264,000 fish a year during the 20-year period from 1915–34. The catch by 5-year intervals during this time was 1,597,246 fish from 1915–19; 1,219,492 fish from 1920–24; 1,380,225 fish from 1925–29; and 1,087,693 fish from 1930–34.

It is exceedingly difficult to obtain catch records for all districts of the region, but data are available for the period from 1927–34 for all districts except the Fraser River. For this district the canned pack has been converted to number of fish and it represents only a part of the early run on the river, but includes the greater part of the fall run. A small number of kings landed by trollers in the northern portion of the Gulf of Georgia have not been included. These data are presented in table 41.

TABLE 41.—*Catch of king salmon, 1927–34*

Year	Puget Sound traps	Purse-seines		Trollers		Puget Sound gill nets	Minor Puget Sound gear	Fraser River catch [1]	Total, all gear
		Puget Sound	High seas	Puget Sound	High seas				
1927	227,909	18,370	6,818	1,870	235,866	37,580	2,033	53,770	584,216
1928	198,443	11,025	4,067	1,651	213,784	31,195	900	11,629	472,694
1929	249,353	14,181	13,817	1,366	206,073	44,485	2,257	23,533	555,065
1930	208,872	17,136	8,791	2,645	235,425	49,934	1,558	51,084	575,445
1931	156,207	21,497	13,957	1,156	245,611	28,522	516	28,712	496,178
1932	137,770	20,670	6,897	192	169,530	20,910	24	84,722	440,715
1933	162,991	23,916	4,596	68	113,512	22,960	667	16,483	345,193
1934	165,013	15,606	10,490	9,337	125,377	19,250	276	46,227	391,576
Total	1,506,558	142,401	69,433	18,285	1,545,178	254,836	8,231	316,160	3,861,082

[1] Converted from cases packed from fish caught on the Fraser River; does not include kings used for purposes other than canning.

The total catch by all gear in the region during these 8 years was 3,861,082 fish. Trollers on the high seas landed 40.02 percent of the total catch, and inside trollers 0.47 percent, a total of 40.40 percent. Puget Sound traps took 39.02 percent of the king catch during these years, Fraser River gill nets 8.19 percent, and Puget Sound gill nets 6.60 percent. Purse seiners on the high seas took 1.80 percent and those on Puget Sound 3.69 percent, a total of 5.49 percent. Landings from miscellaneous gear amounted to 0.21 percent of the total. The catch of trollers in the region of Swiftsure Bank differs from the "inside" gear in that it must, in view of the migrations indicated by tagging experiments, contain a considerable proportion of fish from populations other than those of the Puget Sound-Fraser River region.

LOCALITY OF TRAP CATCHES

A consideration of catch data from traps shows the general proportions of the king-salmon catches in the different parts of the Puget Sound district. These data, from 1895–1934, are presented in table 42. The districts used are similar to those discussed under trap catches of coho salmon in the preceding section.

The total catch of king salmon includes 5,659,793 fish. Of this total, 2,644,524 were taken in traps north of Deception Pass, the greater part of these being from the populations of rivers in the northern part of the region. There were 1,741,479 fish from districts wherein a considerable mixture of populations migrating to both northern and southern streams must be present; 1,128,835 fish were taken in the southern portions of the region, and 144,955 fish were taken in miscellaneous and unidentified areas. These data indicate that the greater portion of the catch of king salmon on Puget Sound is supplied by the populations of the northern rivers, and the size of the catch in the northernmost districts would further indicate that a considerable portion of these populations are migrating to the Fraser River and to the smaller streams entering the Gulf of Georgia.

TABLE 42.—*Annual catch of king salmon in different areas, 1895–1934* [1]

Year	Area												Total
	Point Roberts and Boundary Bay	Sandy Point to Boundary Bay	Lummi Island and Rosario Strait	Haro Strait and Waldron Island	Salmon Banks and South Lopez	Hope Island and Skagit Bay	West Beach	West of Middle Point	Admiralty Inlet	Lower Sound	Miscellaneous	Unidentified	
1895	912												912
1896	10,192		97									788	11,077
1897	1,449	720	3,164		71		3,384						8,788
1898	30,255	3,000	41				94					4	33,394
1899	19,980	4,635	12,286	96	2,814		79	129					40,019
1900	30,979	9,215	364	2,412	20,365	14,755	5,758		8,922		850	4,777	98,397
1901	7,881	4,442	3,568	2,933	5,963	5,180	5,047		461		218	5,410	41,103
1902	5,312	7,681	5,497	5,378	14,891	4,829	9,077		885				53,550
1903	6,005	15,427	5,563	2,489	17,360							121	46,965
1904	15,695	17,478	5,807	2,343	6,960		12,911						61,194
1905	14,105	5,065	4,883	2,080	7,472	9,787	10,469		2,684				56,545
1906	8,731	7,981	8,048	9,081	3,627	5,609	19,103		10,084				72,264
1907	14,952	8,829	6,543		5,011	8,903	34,977		740				79,955
1908	8,843	8,922	8,475	5,761	5,892	9,640	47,986		3,461				98,980
1909	7,374	5,666	9,877		6,911	8,945	19,648		254				58,675
1910	14,542	21,478	18,144		8,307	8,583	24,414		11,505			256	107,229
1911	28,054	26,590	25,996		9,647	4,752	34,090		6,770		380	83	136,362
1912	22,442	19,461	22,785	3,250	4,374	4,374	28,886		3,343		629		109,544

[1] Incomplete before 1915.

TABLE 42.—*Annual catch of king salmon in different areas, 1895–1934*—Continued

Year	Area												Total
	Point Roberts and Boundary Bay	Sandy Point to Boundary Bay	Lummi Island and Rosario Strait	Haro Strait and Waldron Island	Salmon Banks and South Lopez	Hope Island and Skagit Bay	West Beach	West of Middle Point	Admiralty Inlet	Lower Sound	Miscellaneous	Unidentified	
1913	22,349	17,984	20,967	2,126	9,114	4,038	18,306	-------	4,558	-------	-------	14	99,456
1914	36,134	25,585	25,619	3,323	11,838	4,040	15,330	-------	6,479	-------	449	-------	128,797
1915	43,359	15,867	31,878	15,386	20,632	13,903	42,502	13,310	19,712	3,780	4,302	12,553	237,184
1916	40,819	26,219	29,319	14,567	21,222	8,607	46,473	23,917	24,901	1,332	6,327	7,930	251,633
1917	45,172	21,257	26,209	24,795	41,582	16,971	42,975	17,332	26,559	3,321	9,572	9,486	285,231
1918	42,160	34,916	35,773	16,772	35,574	21,057	59,606	25,921	40,478	1,992	10,013	724	324,986
1919	47,869	17,493	19,937	12,382	23,707	22,475	44,627	14,831	32,913	2,639	10,085	448	249,406
1920	58,172	19,053	33,490	4,577	19,781	10,583	35,012	6,104	22,304	3,548	5,109	1,069	218,802
1921	41,573	19,627	17,335	16,268	27,994	13,313	31,681	7,140	23,812	1,678	3,049	1,832	205,302
1922	41,419	16,430	21,333	4,525	17,311	20,234	29,452	9,749	20,630	2,121	3,697	-------	186,901
1923	37,375	17,406	16,860	8,119	22,278	21,409	32,739	6,801	28,246	1,434	16,157	-------	208,824
1924	51,065	16,511	21,775	9,861	16,773	-------	39,123	12,903	35,127	8,117	3,827	-------	215,082
1925	48,491	18,223	24,231	8,746	25,022	21,745	33,844	13,087	33,142	3,526	4,310	-------	234,367
1926	43,639	15,497	18,066	10,899	12,757	17,465	29,641	13,855	31,689	5,330	2,560	367	201,765
1927	53,690	25,463	18,568	8,471	21,230	21,429	38,585	13,897	26,614	3,453	-------	-------	231,400
1928	39,856	16,638	14,583	4,925	16,318	10,779	27,607	11,710	31,689	6,699	385	-------	181,189
1929	48,708	18,557	30,105	9,117	16,389	24,873	35,611	8,937	32,298	10,121	1,504	7,506	243,726
1930	45,431	13,940	22,370	7,507	16,853	25,741	28,201	9,086	31,314	5,153	2,186	-------	207,782
1931	36,912	8,569	17,586	5,573	9,550	20,951	21,630	5,279	23,939	2,015	916	-------	152,920
1932	34,493	4,292	20,943	2,007	13,243	17,626	13,875	7,832	18,818	3,524	-------	-------	136,653
1933	32,407	16,087	23,855	5,965	17,606	12,673	15,072	2,300	40,088	1,305	1,307	2,476	171,141
1934	50,187	10,792	21,143	7,728	15,990	12,164	14,764	12,351	22,606	3,289	1,279	-------	172,293
Total	1,188,983	562,996	653,083	239,462	552,429	427,433	952,579	236,471	627,025	74,377	89,111	55,844	5,659,793

In only one tagging experiment of those reviewed by Pritchard (1934) were the recoveries in southern Puget Sound greater than those in the northern part of the region. The major part of the recoveries of fish tagged in this experiment, on the northeast coast of Vancouver Island, were taken in the vicinity of the mouth of the Skagit River or in the river itself. This stream, which has supplied the greater portion of the kings gill netted in the Puget Sound region, supports the largest run in the southern area. The other tagging experiments confirm the inferences drawn from the trap-catch data as to the importance of the northern streams, since the greater proportion of recoveries made in the inner waters of the region have been taken in the northern districts of Puget Sound or in the Fraser River itself.

SEASONAL OCCURRENCE IN VARIOUS AREAS

The general seasonal occurrence of king salmon in different types of gear has already been presented, but a further consideration of occurrence in traps indicates certain specific differences in the runs in various parts of the region. The occurrence of kings from traps in several restricted areas was calculated in a manner similar to that used for the entire region, see section on trap fishery. The average proportions of the annual catch taken in each week of the season in these different areas are presented in table 43. For location of areas, see figures 2 and 3.

TABLE 43.—*Seasonal occurrence of king salmon from traps; proportion of total catch taken in each 7-day period*

Week ending—	Area						
	North of Sandy Point	Rosario Strait	West Beach	Middle Point	Admiralty Inlet	Hope Island	All districts
Apr. 21						0.556	0.425
Apr. 28			2.724			1.365	1.353
May 5	3.298	2.334	3.595	2.392	3.513	1.587	2.259
May 12	3.089	4.232	3.779	3.799	4.742	1.785	3.212
May 19	3.195	3.808	3.735	4.384	5.875	2.551	3.649
May 26	3.137	3.539	4.469	5.142	4.859	3.265	3.780
June 2	4.056	3.539	4.573	4.713	5.782	3.578	4.166
June 9	4.774	4.354	4.994	4.943	5.481	4.625	4.770
June 16	4.910	4.845	5.456	5.865	5.349	5.151	5.145
June 23	5.421	5.582	7.049	5.835	5.397	7.400	5.921
June 30	5.547	6.140	7.398	5.507	5.742	8.829	6.330
July 7	6.317	7.433	7.736	6.571	5.854	10.796	7.292
July 14	5.679	6.925	6.950	7.028	5.867	8.701	6.696
July 21	5.516	6.267	7.184	6.705	5.618	7.258	6.252
July 28	5.296	6.666	6.552	7.179	6.013	5.925	6.188
Aug. 4	5.069	6,153	6.224	7.191	6.590	6.385	6.072
Aug. 11	5.379	5.961	4.897	8.040	7.418	6.407	6.149
Aug. 18	5.796	5.654	4.430	6.151	5.132	5.776	5.565
Aug. 25	4.768	4.510	3.621	4.272	4.742	4.234	4.456
Sept. 1	5.037	3.693	2.022	2.050	2.554	2.133	3.406
Sept. 8	4.912	3.703	1.277	1.276	1.602	1.042	2.875
Sept. 15	5.011	2.544	.611	.584	.900	.371	2.074
Sept. 22	2.452	1.248	.300	.197	.385	.229	1.105
Sept. 29	.956	.554	.303	.076	.168	.024	.451
Oct. 6	.222	.198	.106	.044	.119	.020	.167
Oct. 13	.145	.063	.014	.039	.074	.007	.069
Oct. 20	.015	.029		.019	.062		.041
Oct. 27	.004	.015			.059		.038
Nov. 3		.011			.073		.064
Nov. 10					.030		.030
Total	100.001	100.000	99.999	100.002	100.000	100.000	100.000

In all areas the run is much more prolonged than that of the other species, and there are no extreme peaks of occurrence. The highest percentages for any single week in the district north of Sandy Point or in Rosario Strait occur in the first week of July. There is an additional run in these areas in late August and September, especially in the more northern one. West Beach, where the catches probably contain a considerable mixture of populations, shows a similar peak in that week, but there is no indication of the late-season run. The southern areas show proportionately higher percentages in the early part of the season, a peak early in August, and an abrupt decrease thereafter. There is also no indication of a late run in these areas.

SEASONAL OCCURRENCE OF RED AND WHITE KING SALMON

Thus far the runs of king salmon have been treated as entities, but some of the distinct differences between their occurrence in northern and southern areas may be explained by a consideration of the proportionate runs of red and white kings in these districts.

The catches of king salmon from certain traps in the region have been segregated as to red and white kings by the operators, especially where the fish were sold for market purposes. Such a segregation into only two classes undoubtedly introduces some errors in the determination of the proper classification of the individuals which intergrade between the color extremes of red and white. Grading has been purely on the

basis of market demand, and the general practice has been to classify the vari-colored fish with the whites, since the reds bring a higher price. The following determinations are necessarily confined to the two main classes, but the presence of intergrading colors must not be overlooked. Data were available for some early years, and for most of the years between 1923 and 1934, for 3 traps in Haro Strait, 3 in Birch Bay, 1 on Lopez Island, and 2 in Admiralty Inlet. The average proportionate occurrence of red and white king salmon throughout the season was calculated for these four areas. These data are presented in table 44.

TABLE 44.—*Seasonal occurrence of red and white king salmon in different areas; proportion of total catch taken in each 7-day period*

Week ending—	Red king					White king				
	Haro Strait	Birch Bay	Haro Strait and Birch Bay	South Lopez	Admiralty Inlet	Haro Strait	Birch Bay	Haro Strait and Birch Bay	South Lopez	Admiralty Inlet
May 5				3.696	3.569				0.380	3.054
May 12	3.400		4.658	6.181	4.986	0.163		0.266	2.296	2.883
May 19	3.758	9.053	5.199	7.398	6.001	.713	3.209	1.391	8.466	4.760
May 26	5.645	4.799	5.533	6.887	4.947	.909	1.399	1.140	2.546	3.625
June 2	4.101	3.410	4.000	6.193	5.442	.769	1.567	1.051	2.133	5.398
June 9	5.614	8.932	6.437	5.555	5.347	.979	2.775	1.505	2.438	6.247
June 16	5.297	6.881	5.624	6.118	5.209	.952	1.791	1.231	3.003	5.415
June 23	6.709	6.543	6.493	6.267	5.209	1.343	2.059	1.619	3.613	5.637
June 30	5.052	6.422	5.323	6.095	5.665	1.161	1.522	1.333	3.352	6.034
July 7	4.856	5.718	4.985	7.325	6.023	.865	1.985	1.210	5.663	6.496
July 14	5.727	5.689	5.573	6.374	5.746	1.094	3.448	1.769	6.323	6.350
July 21	5.953	3.352	5.050	6.180	5.483	.849	2.089	1.223	7.643	5.604
July 28	5.989	5.718	5.761	6.374	5.981	1.583	3.396	2.154	5.713	5.993
Aug. 4	5.357	6.281	5.491	5.812	6.681	1.926	5.120	2.872	9.090	6.560
Aug. 11	10.988	6.957	9.544	4.774	7.514	3.608	4.179	4.003	9.953	7.565
Aug. 18	4.904	6.534	5.254	4.018	5.361	3.232	4.806	3.856	7.669	4.714
Aug. 25	5.787	3.746	5.050	3.060	4.740	3.526	3.134	3.670	6.475	6.170
Sept. 1	4.183	4.021	4.115	1.066	2.587	6.398	13.671	8.777	5.472	2.457
Sept. 8	3.365	2.298	2.562	.360	1.611	35.849	12.662	25.931	3.383	2.403
Sept. 15	2.267	.739	1.724	.158	.926	27.491	10.186	24.348	1.676	1.203
Sept. 22	.603	.845	.701	.041	.360	5.443	10.521	7.551	1.490	.834
Sept. 29	.150	2.060	.542	.051	.161	.948	10.480	2.835	.702	.332
Oct. 6	.057		.058	.015	.125	.137		.164	.057	.084
Oct. 13	.134		.184		.078	.061		.100	.129	.043
Oct. 20	.102		.140		.070				.335	.016
Oct. 27					.067					.016
Nov. 3					.075					.109
Nov. 10					.035					
Total	99.998	99.998	100.001	99.998	99.999	99.999	99.999	99.999	100.000	100.002

Occurrence of red kings does not differ materially in the various areas, although there is a greater early run in the northern districts and a heavier run in the Admiralty Inlet area. White kings differ considerably, however, with heavy fall concentrations in the northern areas. More than 75 percent of the season's catch in Haro Strait is made during the month of September, as is approximately 60 percent of the catch in Birch Bay. Occurrence of white kings in the southern portion of Rosario Strait (South Lopez) is more even throughout the season, the peak of the run appearing during the month of August, while in Admiralty Inlet no definite peak of occurrence is shown.

The average proportion of white kings in the total catch of red and white kings combined was then calculated for each week in the season and for the total season from the trap catches of the various areas. These data are presented in table 45.

In order to determine the proportionate occurrence of red and white kings in both northern and southern runs, the weekly percentages of kings from table 43 were divided as to proportion of red and white kings on the basis of the data presented in table 45. Since percentages were not available for the entire area north of Sandy Point, a combination of the Haro Strait and Birch Bay proportions were used for this northern district. Proportionate seasonal occurrence in the area north of Sandy Point is shown graphically in the upper section of figure 28, that of Admiralty Inlet in the lower section of the same figure.

Table 45.—*Proportion in each 7-day period of white king salmon in total king salmon catches in different areas*

Week ending—	Area				
	Haro Strait	Birch Bay	Haro Strait and Birch Bay	South Lopez	Admiralty Inlet
[illegible]				2.646	7.358
[illegible]	3.390		3.390	8.921	5.101
[illegible]	12.057	16.045	14.124	23.182	6.857
[illegible]	10.393	13.587	11.236	8.884	6.367
[illegible]	12.001	19.858	13.903	8.326	8.431
[illegible]	11.909	14.352	12.539	10.370	9.785
[illegible]	11.804	12.308	11.855	11.462	8.800
[illegible]	12.706	14.511	13.283	13.196	9.128
[illegible]	14.886	11.333	13.341	12.664	8.995
[illegible]	11.522	15.768	12.981	16.932	9.099
[illegible]	12.246	24.627	16.319	20.733	9.302
[illegible]	9.457	23.357	12.978	24.592	8.665
[illegible]	15.194	24.254	18.685	19.116	8.510
[illegible]	20.811	35.530	24.324	29.201	8.352
[illegible]	18.372	24.465	20.490	35.475	8.545
[illegible]	32.612	28.395	31.083	38.481	7.545
[illegible]	30.825	31.988	30.872	35.815	10.779
[illegible]	52.778	64.706	56.720	57.513	8.102
[illegible]	88.020	74.815	86.170	71.242	12.165
[illegible]	89.893	88.126	89.068	73.684	10.759
[illegible]	86.830	87.037	86.885	90.566	17.699
[illegible]	82.108	73.288	79.246	78.261	16.107
[illegible]	63.636		63.636	50.000	5.825
[illegible]	25.000		25.000		4.839
[illegible]					1.961
[illegible]					2.128
[illegible]					11.765
[illegible]	34.191	31.503	33.390	20.295	8.665

The two peaks of occurrence of red kings, in early July and in late August, in the northern area may be compared to the sustained run in the southern area, where the highest percentages occur in early August. The run in both areas diminishes uniformly during late August and early September.

The run of white kings in the northern area is in striking contrast to that of Admiralty Inlet. In the latter area the white kings form a very small proportion of the run and are distributed throughout the season. In the northern area, however, they form a considerable portion of the run in the early part of the season, become increasingly important in midsummer, and form the major part of the run from early September to the end of the season. It thus appears that the more prolonged occurrence of king salmon in the northern areas is due to the presence of a considerable run of white kings, and that the major portion of white kings caught in the region must have been contributed by the populations of the Gulf of Georgia streams.

CHANGES IN ABUNDANCE

Traps are the only major gear taking king salmon for which sufficient data are available for any determination of changes in abundance of this species. The records of this gear are inadequate prior to 1910, but the following calculations are presented as the best measure which can be determined from present data.

The data were necessarily restricted, because of fishing seasons of varying lengths, to include only those traps for which the opening fishing dates for each season were known. The catches of all traps were then weighted according to the length of the season fished in a manner similar to that discussed under the trap index for coho salmon.

Suitable data from the area north of Sandy Point were available for the period from 1910–34. During these years, from 6 to 11 traps fished in each year except 1932. Four of these traps were in Birch Bay, 4 in Bounday Bay, and 3 at Point Roberts. During the same period of time, data were available from 2 traps in Rosario Strait for every year except 1910. In Admiralty Inlet, data were available between 1916 and 1934 from 4 traps, at least 2 of which fished in every year except 1916 and 1932. The number of traps fishing in each area, and their combined catches, are presented in table 46.

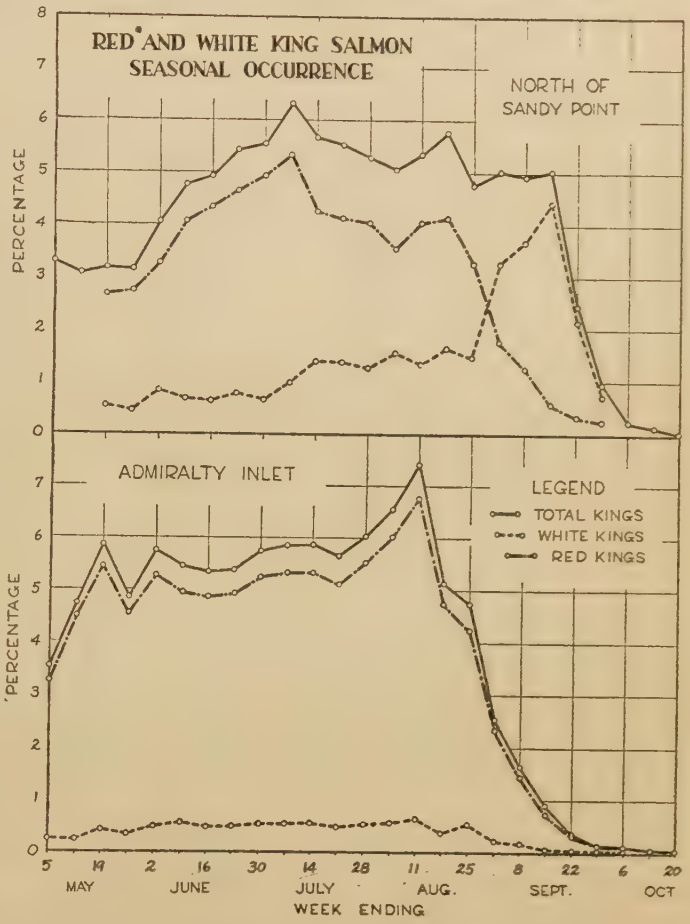


FIGURE 28.—Seasonal occurrence of red and white king salmon in trap catches of the northern and southern districts of Puget Sound. The greater abundance of white kings and the heavy late-season run in the northern district are apparent.

TABLE 46.—*Indices of abundance of king salmon from traps*

Year	Data by areas						Index figures		
	North of Sandy Point		Rosario Strait		Admiralty Inlet		North of Sandy Point	Rosario Strait	Admiralty Inlet
	Number of fish	Number of traps	Number of fish	Number of traps	Number of fish	Number of traps			
1910	20,824	6	12,053	1			1.611	1.741	
1911	28,475	6	19,265	2			2.110	1.780	
1912	31,841	9	13,904	2			1.631	1.382	
1913	22,806	6	9,844	2			1.747	1.007	
1914	31,317	7	13,385	2			1.966	1.344	
1915	23,110	8	11,106	2			1.145	1.168	
1916	29,577	8	7,808	2	4,869	1	1.661	.920	2.394
1917	27,640	8	9,367	2	11,420	2	1.627	.974	3.362
1918	35,562	8	13,432	2	17,244	2	2.290	1.416	5.105
1919	32,308	9	10,166	2	9,728	2	1.744	1.017	2.975
1920	44,266	7	19,595	2	16,279	4	2.859	1.848	1.548
1921	38,922	9	10,227	2	14,359	2	2.088	1.053	2.216
1922	39,717	7	18,333	2	7,217	2	2.676	1.675	1.937
1923	28,078	7	11,464	2	21,996	4	1.962	1.096	2.160
1924	46,926	8	11,650	2	28,693	4	2.887	1.061	2.645
1925	48,234	10	10,500	2	18,407	4	1.915	1.020	1.974
1926	36,890	10	10,749	2	16,220	4	1.534	1.071	1.640
1927	51,161	11	10,060	2	11,638	3	2.057	1.056	1.494
1928	26,972	9	7,129	2	7,915	3	1.590	.775	1.034
1929	44,423	10	11,287	2	12,862	4	1.868	1.113	1.368
1930	27,112	11	12,656	2	9.428	4	1.274	1.292	1.054
1931	24,914	10	7,060	2	3,927	2	1.204	.940	.697
1932	2,764	2	19,703	2	5,223	1	1.428	1.964	1.927
1933	16,559	7	13,431	2	11,046	3	1.529	1.325	1.426
1934	38,405	9	11,952	2	4,407	2	2.094	1.116	.947
Total	798,803		306,126		232,878				

Indices of abundance for these three areas, calculated in the same manner as were those from traps for coho salmon, are presented in the last three columns of table 46. The indices are high for the northern areas during the post-war period prior to 1925. Increased catches during this period may be due in part to the lesser competition of trolling gear, which fishes the runs before they reach the traps. The number of trolling licenses issued by the State of Washington for the Puget Sound district decreased from 1,032 in 1919 to 165 in 1922, and then increased considerably in number to 820 in 1927 (see table 23). There is little difference in levels of abundance in early and late years in the two northern areas.

In Admiralty Inlet, however, abundance is highest before 1920 and reaches a lower level by 1924; a decrease in the size of the runs in recent years is strongly indicated.

PINK SALMON

By George A. Rounsefell

GENERAL LIFE HISTORY

Because pink salmon invariably mature in their second year, as has been well established, there is no overlapping of generations as in the sockeye, king, and chum salmon, and, in some regions, in the coho. In this region there is an abundant run of pink salmon every second year, in the odd-numbered years. They spawn in scores of small streams, as well as the lower tributaries of the main rivers. In the Fraser River they even spawned above Hell's Gate in Seton and Anderson lakes and the Nicola and Thompson rivers until the blockade at Hell's Gate in 1913, which, coming in an odd-

numbered year, destroyed this up-river run. In the even-numbered years no pink salmon spawn in Puget Sound streams or in the Fraser River, although a few thousand are usually caught north of Deception Pass. Most of these pinks are probably bound to the streams in the northern end of the Gulf of Georgia, which have pink runs in both odd- and even-numbered years.

The pink-salmon fry, upon emerging from the gravel, migrate at once to the sea, which permits great numbers to propagate in streams that might be unsuitable for the support of large numbers of young fish.

Recently evidence has been gathered on the homing instinct in pink salmon. Pritchard (1934) in an experiment at McClinton Creek, Masset Inlet, in which 108,000 fry were marked by clipping of fins before being liberated, recovered 3,285 when they returned from the sea as adults. Of this total, over 3 percent of the number marked, only 7 fish were taken outside of the Queen Charlotte Islands, and 2,950 were recaptured in the same creek. Davidson (1934) in an earlier experiment marked 50,000 pink fry at Olive Cove, Alaska. Twenty-three marks were recovered there from 7,944 adult salmon dipped over the counting weir. Since 10,640 of the run were not examined for scars the total number of marked fish in the run was calculated as 54.

MIGRATION

Information is scarce on the migrations of pink salmon in the region. Pritchard (1930) tagged 205 pinks in Johnstone Strait in 1928. All of the recoveries were made in local streams. In 1929 the experiment was repeated (Pritchard, 1932) and out of 468 tagged in the same area 37 were recovered, 20 in the Fraser River, and 1 at West Beach, Whidbey Island. None were recaptured farther to the north than the point of tagging. The difference between the 1928 and 1929 results was quite as expected, since Puget Sound and the Fraser River support a tremendous run of pinks in the odd-numbered years, but almost none in the even-numbered years. The recoveries show that a fair share of the run to this region may ordinarily come around the north end of Vancouver Island.

Pink salmon were also tagged in 1929 from the traps at Sooke. Out of 185 released there were 14 recoveries, 1 at the point of tagging, 6 in Puget Sound waters (3 from north of Deception Pass), and 7 in the Fraser River.

METHOD AND LOCALITY OF CAPTURE

The Swiftsure Bank-Puget Sound-Fraser River pink salmon catch from 1925–34 amounts to 52,240,000 fish, excluding Vancouver Island and the Gulf of Georgia for which sufficient data are not at hand (see table 47). Previous to 1925 data are lacking on the Swiftsure Bank catch or of the amounts canned on the Fraser River that were not shipped in from other districts.

TABLE 47.—*Catch of pink salmon, 1925–34*

Year	Fraser River catch [1]	Puget Sound traps	Purse seines		Miscellaneous Puget Sound gear	Total
			Puget Sound	High seas		
1925	1,355,592	1,950,468	4,602,188	729,702	108,386	8,746,336
1926	19,236	21,669	1,764	1,529	1,052	45,250
1927	1,378,762	3,062,604	3,341,419	2,136,570	125,142	10,044,497
1928	938	5,882	3,445	68,877	114	79,256
1929	1,957,760	2,945,720	4,365,513	3,373,529	152,962	12,795,484
1930	13,118	7,057	9,520	42,058	738	72,491
1931	186,298	3,688,006	4,346,600	3,903,188	52,110	12,176,202
1932		3,678	5,130	5,981	21	14,810
1933	1,298,766	1,729,775	4,298,591	844,895	58,384	8,230,411
1934	4,788	2,964	10,044	20,096	117	38,009
Total	6,215,258	13,417,823	20,984,214	11,126,625	499,026	52,242,746

[1] Converted from cases at 14 per case, does not include pinks caught elsewhere in the Gulf of Georgia and canned on the Fraser River.

The purse seines are the most important factor, accounting for 32 million fish, or about 60 percent of the total catch, during the past 10 years. Purse seines do better, compared to the traps, in taking pinks than they do in the capture of sockeyes. The pink salmon swim in dense schools, frequently jumping or "finning," so that the schools are much easier to locate. Also, a much larger proportion of the pinks may use Haro Strait than is the case with the sockeyes, as the pinks that are bound northward spawn not only in the Fraser River, but in a number of smaller rivers and streams entering the Gulf of Georgia from both the mainland and Vancouver Island shores, and, since only a few traps are favorably located to capture fish using Haro Strait they would catch relatively less.

Accurate data on the locality of capture is available for the trap-caught pinks. Traps north of Deception Pass have taken over 45 million, whereas the southern traps have caught but 9 million, or a proportion of 5 to 1. During the past 10 years the proportion has been 2 to 1; 9 million northward and 4½ million to the south.

The records of one large company over a 7-year period show that the bulk of the seine-caught pinks are from the Salmon Bank area, with large numbers from around Stuart Island and Mitchell Bay in Haro Strait, and also from Lummi Island, Birch Bay, Boundary Bay and Point Roberts areas, only minor quantities being captured south of Deception Pass. It would thus appear that a large proportion of the pink salmon captured in Puget Sound waters, probably well over half, are bound toward Canadian spawning grounds.

TABLE 48.—*Pink salmon caught by traps north of Deception Pass* [1]

Year	Point Roberts and Boundary Bay	Birch Bay [2]	Rosario Strait and Lummi Island	Haro Strait and Waldron Island	Salmon Bank	South Lopez	Undetermined	Total
1895	28,660							28,660
1896								
1897	38,637	9,026						47,663
1898								
1899	1,198,461	56,861	4,555	24,493	353,640		6,634	1,644,644
1900								
1901	59,564	94,246	19,068	28,139	38,956			239,973
1902								
1903	959,905	6,062	66,988	175,270	198,195		88,287	1,494,707
1904								
1905	236,504	79,526	55,825	75,138	81,522			528,515
1906								
1907	1,885,463	708,077	472,717		397,916			3,464,173
1908	278	449	280	761	838			2,606
1909	1,992,165	809,846	1,472,042	50,260	387,316			4,711,629
1910	457	22	139		335			953
1911	3,049,686	1,227,578	1,180,549	83,396	650,980	168,520	35	6,360,744
1912	3,309	2,076	381	371	774			6,911
1913	2,211,470	1,471,812	1,443,287	715,922	685,701			6,528,192
1914	1,308	3,279	2,448	1,200	5,654	19		13,908
1915	744,701	166,854	519,415	160,924	117,114	83,287		1,792,295
1916	129	161	96	206	232	36		860
1917	1,777,330	584,472	536,769	386,945	306,233	161,085		3,752,834
1918	8,822	12,838	13,146	3,203	6,905	3,084		47,998
1919	932,419	272,762	248,654	201,849	203,004	79,801		1,938,489
1920	3,753	2,470	3,180	434	832	538		11,207
1921	723,232	200,577	167,678	170,399	157,478	87,867		1,507,231
1922	7,706	3,547	4,440	2,108	3,234	2,888		23,923
1923	974,883	173,289	252,037	235,262	153,731	67,812		1,857,014
1924	25,714	8,096	7,764	17,054	12,683	8,831		80,142
1925	834,226	65,300	158,589	276,117	201,707	93,034		1,628,973
1926	7,515	4,427	2,626	2,674	1,011	474		18,727
1927	1,124,516	223,548	333,276	248,316	162,896	221,063		2,313,615
1928	1,692	1,011	867	549	615	329		5,063
1929	805,697	113,454	409,851	247,587	169,910	89,595		1,836,094
1930	1,485	1,436	1,040	477	243	309		4,990
1931	648,250	183,059	598,836	267,078	132,664	95,035		1,924,922
1932	355	558	148	77	251	730		2,119
1933	490,513	132,857	134,507	131,061	161,709	93,877		1,144,524
1934	1,264	566	380	336	126	98		2,770
Total	20,780,069	6,620,142	8,111,578	3,507,606	4,594,405	1,258,312	94,956	44,967,068

[1] Incomplete before 1915.

[2] Including Alden Bank.

TABLE 49.—*Pink salmon caught by traps south of Deception Pass* [1]

Year	West Beach	Hope Island	Middle Point and Ebeys Landing	Admiralty Bay and Bush Point	Oak Bay and Hood Canal	Useless Bay and Point No Point	Meadow Point and south	South side Strait of Juan de Fuca	Total [2]
1897	125								125
1898									
1899	5,050								5,050
1900									
1901	400	14,383		9,455					24,238
1902		429							429
1903	15,816								15,816
1904									
1905	18,498	19,613		10,859					48,970
1906									
1907	123,140	61,044		417,812		53,356			655,687
1908	333	2							335
1909	90,506	553							91,059
1910	59								59
1911	64,288	10,745	160,303	146,062					381,398
1912	302	9							311
1913	285,221	44,721	128,757	110,772					570,195
1914	782		113	10					905
1915	145,771	109,971	160,507	558,897	15,052	32,470	32,000	24,714	1,079,382
1916	522	6	92	22		7		92	741

[1] Incomplete before 1915.

[2] Total for 1913 includes 724 with locality undetermined.

TABLE 49.—*Pink salmon caught by traps south of Deception Pass*—Continued

Year	West Beach	Hope Island	Middle Point and Ebeys Landing	Admiralty Bay and Bush Point	Oak Bay and Hood Canal	Useless Bay and Point No Point	Meadow Point and south	South side Strait of Juan de Fuca	Total
1917	107,709	56,783	121,128	273,722	10,815	29,909	14,936	37,998	653,000
1918	5,989	751	1,886	898	55	106	----------	838	10,523
1919	12,791	11,601	11,990	56,553	6,869	6,033	1,800	1,736	109,373
1920	1,412	10	197	1,164	1	13	----------	170	2,967
1921	76,416	72,308	36,034	201,839	----------	32,274	----------	33,176	452,047
1922	1,158	147	313	434	75	----------	46	258	2,431
1923	52,562	50,790	32,545	422,933	29,625	10,357	6,180	10,453	615,445
1924	3,188	----------	724	1,062	137	10	37	921	6,079
1925	45,710	33,497	33,068	161,496	2,552	13,859	4,509	26,804	321,495
1926	1,181	80	486	304	21	1	73	796	2,942
1927	130,280	74,019	56,265	414,171	----------	6,311	18,669	49,274	748,989
1928	228	----------	109	323	----------	----------	----------	159	819
1929	224,968	150,968	118,409	461,574	9,351	15,420	18,979	109,957	1,109,626
1930	590	105	549	326	16	8	----------	473	2,067
1931	249,637	166,426	210,816	987,625	15,409	12,999	20,673	99,499	1,763,084
1932	59	135	164	591	----------	----------	14	596	1,559
1933	90,892	42,847	100,532	312,500	----------	32,578	3,955	1,947	585,251
1934	36	5	25	56	----------	----------	----------	72	194
Total	1,755,619	921,948	1,175,012	4,551,460	89,978	245,711	121,871	399,933	9,262,256

SEASONAL OCCURRENCE IN NORTHERN AND SOUTHERN DISTRICTS

The southern pink salmon runs are earlier than the northern. The southern run, south of Admiralty Head, Ebeys Landing, Admiralty Bay, and Bush Point areas, reaches its peak about August 22, the northern run, areas north of Deception Pass, about September 1, making a difference of about 10 days in the modes. By August 11 about 22 percent of the southern run has passed, but only about 2½ percent of the northern. By September 8, over 95 percent of the southern run has appeared, as against 78 percent of the northern.

This difference in time of run of trap-caught pinks in the two districts is good evidence of the existence of different populations or groups of populations. It is therefore necessary to allow a sufficient number of spawners in each district, as either one can doubtless be depleted regardless of the size of the escapement to the other.

CHANGE IN ABUNDANCE BETWEEN EARLY AND LATE YEARS

In the earlier years pink salmon were evidently tremendously abundant. Rathbun (1899) says that in 1891 four drag seines operating for the Seattle cannery caught 275,000 pinks, but this number represented only a small part of the fishery in progress that year. At that time, and for a few years thereafter, pinks were canned only in Seattle, the output finding a ready sale at a low price in the southern part of the United States.

TABLE 50.—*Seasonal occurrence in traps of odd-year pink salmon in northern and southern districts, 1919–33*

Week ending	North of Deception Pass [1]		South of Admiralty Head [2]	
	Percentage	Cumulative percentage	Percentage	Cumulative percentage
May 26			0.003	0.003
June 2			.004	.007
June 9			.010	.017
June 16			.011	.028
June 23			.014	.042
June 30			.019	.061
July 7			.034	.095
July 14	0.002	0.002	.051	.146
July 21	.037	.039	.302	.448
July 28	.167	.206	2.759	3.207
Aug. 4	.616	.822	6.704	9.911
Aug. 11	1.756	2.578	11.994	21.905
Aug. 18	4.654	7.232	15.579	37.484
Aug. 25	14.270	21.502	27.969	65.453
Sept. 1	29.787	51.289	17.887	83.340
Sept. 8	27.045	78.334	12.136	95.476
Sept. 15	13.855	92.189	3.464	98.940
Sept. 22	6.508	98.697	.395	99.335
Sept. 29	1.001	99.698	.659	99.994
Oct. 6	.208	99.906	.006	100.000
Oct. 13	.080	99.986	.001	100.001
Oct. 20	.007	99.993		
Oct. 27	.005	99.998		
Number of fish	2,537,611		1,929,504	
Number of traps	9		7	

[1] Week ending Sept. 15, empirically determined.

[2] Week ending Sept. 1, empirically determined.

Speaking of the trap fishery Rathbun says:

The trap nets would appear, however, to afford the best means for the capture of the humpback in the salt water, and they are sometimes so taken in immense quantities during the sockeye run. In fact, they often compose by far the larger part of the catch, and as it is generally impracticable to do the sorting in the water at the net, the entire catch may be emptied into scows and the overhauling take place at the wharves. Here the humpbacks are culled out and discarded, causing a wholesale destruction of the species.

In addition to discarding pink salmon, the traps were often closed in odd-numbered years while some sockeyes were still available, in order to avoid capturing the later-running pink salmon for which they had no use. Owing to these factors during the early years of the fishery, the total catch figures are entirely unreliable for measuring abundance. Since the total catches of the individual traps do not give us an adequate measure of abundance in these years the problem has first been attacked by plotting the frequency distributions of the pink-salmon catches of all regularly operated traps north of Deception Pass in the odd-numbered years from 1899–1933 (see table 51).

From 1899–1905 there was practically no demand for pink salmon, and only small quantities were used; the remainder was discarded. This is especially obvious in 1901 and 1905, both of which were big years for sockeye.

TABLE 51.—*Pink salmon catch per trap north of Deception Pass*

Catch in thousands	1899	1901	1903	1905	1907	1909	1911	1913	1915	1917	1919	1921	1923	1925	1927	1929	1931	1933
0	15	29	14		1	5		7										
0–10	7	24	17	35	1	7		2	26	14	5	9	7	18	10	28	9	19
10–20	4	4	6	7	2	5	1	9	20	12	12	18	11	9	6	10	11	12
20–30	2	2	1	9		2		2	9	11	7	12	9	7	7	11	10	2
30–40	1	1	7	1	5	3	2	2	1	8	10	5	3	5	9	5	6	6
40–50			5		5	5	1	5	6	4	5	4	2	5	4	4	7	3
50–60	5	1	2		6	6	3	4	1	5	5	4	6	2	7	2	2	3
60–70				1	5	4	1	3	2	5	3	1	3	3	5	3	1	2
70–80	1				6	3	2	4	1	5		1	1	1	2	2	1	1
80–90	1				3	3	8	2	1	5	2	1	2	1			1	
90–100	1		1		1	1	2	1		2	1				1		1	
100–110				1	3	1	3		3				1		3	1	2	
110–120			1			1	1	2		1	1			1				
120–130					1	2	3			1								
130–140							2	1					1			1		
140–150								4						1				
150–160			1		1	1		2					1					
160–170						1	1	1		2								
170–180					1		2	5										
180–190	1				1	1	2	1		1								
190–200						3	1	1										
200–210					2			1										
210–220					1		1	1										
220–230																		
230–240																		
240–250						1												
250–260						1	2	1										
260–270							2	1										
270–280																		
280–290							2	1										
290–300																		
300–310							1	1										
310–320																		
320–330																		
330–340																		
340–350																		
350–360								1										
360–370						1		1										
370–380																		
380–390																		
390–400							1											
400–410																		
410–420																		
420–430																		
430–440																		
440–450																		
450–460						1												

In 1907 there was some demand for pinks and the medium take per trap was over 60,000. In 1909, a big sockeye year, only 50,000 per trap were utilized. In 1911, with a small sockeye run and an increasing demand for pinks, the median catch per trap was over 100,000. The median catch per trap was only 60,000 in 1913, again a big sockeye year, but on comparing it with 1911 and 1909 it is obvious that in the big years, either no pinks, or very few, were used from many of the traps. Eliminating those traps taking less than 20,000 pinks from the 1913 distribution, and they are not part of the distribution, as shown by 1911, the median catch is over 110,000.

Since 1913 the demand for pink salmon has been good, and yet the highest median catch, in 1917, has only been over 30,000 per trap. If this evidence of a tremendous decline in abundance is not sufficiently convincing, one needs but note the size of the maximum trap catches.

In the past 10 cycles, 1915–33, only 8 trap catches have exceeded 120,000 pink salmon, yet in the 8 earlier years this was exceeded 64 times. Considering only the earlier years when there was some demand, 1907–13, it was exceeded 62 times. In the same 4 cycles 29 catches were made of over 190,000—larger than any single

catch in the past 10 cycles. Therefore, we must conclude that a tremendous decline in the abundance of pink salmon took place between 1913 and 1915.

INDICES OF ABUNDANCE FROM TRAPS

Because of the great difference in the time of the run between the northern and southern pinks, separate indices were made for the two districts. For the district north of Deception Pass 31 traps were selected fishing in the 14 odd years between 1907 and 1933, and taking 21,051,873 pinks, up to and including September 8 of each year. To use a longer season was impractical as the traps did not fish late during the early years and were subjected to a 10-day closed period from September 6–15 in the later years.

The 31 traps selected were distributed as follows: Point Roberts 3, Boundary Bay 9, Birch Bay 6, Lummi Island 4, Salmon Bank 4, South Lopez 2, Rosario, Waldron Island, and Haro Strait areas 1 each. The index was calculated in the same manner as described for sockeye. For a standard curve 12 traps were used, 3 each from Boundary Bay and Birch Bay areas, 2 each from Lummi Island and Salmon Bank areas, and 1 each from Point Roberts and Rosario Strait areas. The standard covered the years from 1911–31.

For the southern district only 7 traps were available, 2 from Middle Point area, 2 from Admiralty Bay, and 3 from Bush Point. For a standard curve all 7 traps were used for the 4 odd years from 1923–29.

The northern index (table 52) shows a tremendous fall in abundance after 1913. In 1911 and 1913 the index was 284, in the following 20 years, 10 odd years, it has averaged 67.7 or about 24 percent of the former level.

The reason for this sudden drop in abundance can best be explained by the following quotation from the Report of the British Columbia Commissioner of Fisheries for 1915:

> . . . That there would be a great decrease in the run of pink salmon to the Fraser River District this year was clearly indicated in the Department's report from the spawning grounds in 1913. Owing to the blockade in the canyon of the Fraser at Hell's Gate in 1913, no pink salmon were able to reach the spawning-beds in the waters above that point. Up to that year countless millions spawned in the Thompson and Nicola Rivers and in the vicinity of Seton Lake. As is shown in our report for the spawning-beds this year, no pinks reached those waters.

Since, as pointed out above, the pinks invariably mature at two years of age, the very abundant odd-year run of pinks spawning in the Fraser River above Hell's Gate Canyon was completely wiped out.

TABLE 52.—*Pink salmon index of abundance from traps north of Deception Pass, 1907–33*

Year	Catches	Efficiency weights	Number of traps	Index of abundance	Year	Catches	Efficiency weights	Number of traps	Index of abundance
1907	1,403,010	689,171	10	203.579	1921	967,059	1,731,927	30	55.837
1909	1,220,370	343,969	5	354.791	1923	1,354,003	1,556,160	26	87.009
1911	4,136,212	1,453,493	24	284.570	1925	937,627	1,581,422	27	59.290
1913	3,487,853	1,225,884	20	284.517	1927	1,395,948	1,556,160	26	89.705
1915	909,462	1,833,634	31	49.599	1929	947,559	1,500,928	27	63.132
1917	1,517,903	1,713,587	29	88.580	1931	1,262,263	1,520,336	24	83.025
1919	988,092	1,557,144	25	63.455	1933	524,512	1,394,611	23	37.610

The southern pink-salmon index is very different from the northern (see table 53). There was no fall after 1913 because the Hells Gate slide, which so seriously affected the northern run, had, of course, no effect on the spawning grounds of the southern run.

From 1915–33 the two indices differ at many points, the northern index not showing the extreme fluctuations of the southern. In 1919 the southern abundance was extremely low, possibly due to the intense fishery of 1917. The highest point reached was in 1931. In this southern district our data show no depletion within a recent year.

TABLE 53.—*Pink salmon index of abundance from traps south of Deception Pass, 1907–33*

Year	Catches	Efficiency weights	Number of traps	Index of abundance	Year	Catches	Efficiency weights	Number of traps	Index of abundance
1907	400,054	185,762	2	215.358	1921	223,143	134,863	3	165.459
1909					1923	495,933	432,280	7	114.725
1911	314,603	290,426	3	108.325	1925	254,732	432,280	7	58.928
1913	154,210	134,375	1	114.761	1927	492,875	432,280	7	114.018
1915	531,439	338,059	5	157.203	1929	485,619	432,280	7	112.339
1917	432,541	397,919	6	108.701	1931	813,810	239,527	4	339.757
1919	49,891	397,919	6	12.538	1933	334,525	290,914	5	114.991

ABUNDANCE FROM PURSE-SEINE CATCHES

The purse-seine catches have been a fairly reliable guide to the abundance of pink salmon in Puget Sound since 1911, except in 1913 and to some extent in 1917, as they were usually the chief object of the summer seine fishery. To measure the abundance the average catch per seine boat delivery has been employed, using all of the catches made from August 5–September 8, inclusive, these 5 weeks taking in all of the important part of the season.

Because of the difference in efficiency between purse-seine vessels of different size, the number of deliveries made by vessels of each 5-net-ton class was tabulated separately, and then weighted according to the efficiency scale for all species (see p. 738). The weighted numbers of deliveries for all sizes of purse-seine vessels were pooled, as were the catches, and the average catch per weighted delivery calculated (see table 54).

TABLE 54.—*Pink salmon abundance from Puget Sound purse seines*

Year	Number of fish	Number of catches	Weighted number of catches	Average catch	Year	Number of fish	Number of catches	Weighted number of catches	Average catch
1911	441,920	194	175.6	2,516.63	1923	1,493,749	1,136	1,621.7	921.10
1913	471,627	272	301.3	1,565.31	1925	1,514,755	745	1,067.4	1,419.11
1915	1,059,304	1,558	1,866.2	567.63	1927	1,800,778	1,497	2,181.5	825.48
1917	763,626	705	898.3	850.08	1929	3,686,797	3,019	4,546.0	811.00
1919	251,337	272	391.0	642.81	1931	3,399,825	3,678	5,765.5	589.68
1921	699,099	982	1,408.0	496.52	1933	3,677,705	5,003	7,719.3	476.43

COMPARISON OF PURSE SEINE AND TRAP INDICES

The indices of abundance from Puget Sound purse seines and northern traps are compared in figure 29. The similarity between the indices is striking, as in only 2 out of 12 years do they show any degree of divergence, namely 1913 and 1925.

In 1913 the purse seiners were fishing primarily for sockeyes. Consequently, when the sockeye run was over the seiners quit; only 4 out of 272 catches being made in the last week of the 5-week period covered, and 89 catches being made in the first week; before the pinks were really abundant. For this reason the difference in level of the curves in 1913 cannot be considered significant. In 1925 the purse-seine curve is considerably higher than the northern trap curve, but the data do not suggest any reason for this difference.

The purse seines take large quantities of pink salmon from the areas north of Deception Pass, and the close correspondence with the northern trap index would seem to indicate that the southern run does not contribute much to their catch. Correlating the northern trap index with the average purse-seine delivery gives a coefficient of correlation of .8468 with a probability of less than .01. Such a high correlation certainly indicates that they are drawing largely upon the same general population.

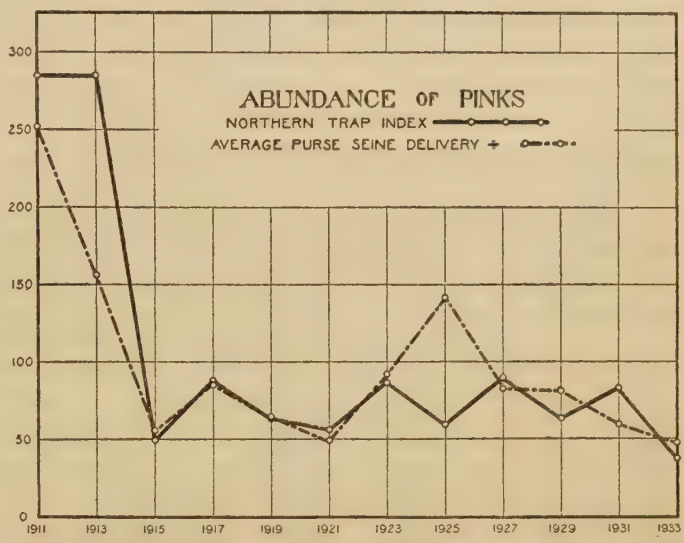


FIGURE 29.—Showing two measures of the abundance of pink salmon. One measure is an index calculated from the catches of Puget Sound traps located north of Deception Pass. The other measure of abundance is the average weighted purse-seine delivery for the period from August 5 to September 8, inclusive. The average purse-seine delivery has been plotted to one-tenth scale to facilitate comparison between the two measures. Note their close correspondence.

CHUM SALMON

By George A. Rounsefell

GENERAL LIFE HISTORY

Chum salmon spawn in the lower tributaries of the main rivers of the region as well as in a great many of the smaller streams. They are the latest running of the Pacific salmons; although there are runs that reach some streams as early as September, the bulk of the run is much later. In earlier years chums were often seined in salt water as late as January. As with the pink salmon, the chum-salmon fry, upon emerging from the gravel of the spawning beds, migrate to salt water.

Because less is known of the life history of the chums than of the other species of Pacific salmon, data were collected during the 1935 fishing season on several hundred adults. Out of 890 individuals taken in Admiralty Inlet between October 10 and November 11, the scales could be read for age on 875. Of these there were 334 three-year-olds, 463 four-year-olds, and 78 five-year-olds, or percentages of 38, 53, and 9. However, none of these percentages are more than an indication of the true proportion, since the percentage of 3-year-olds increases, and that of 5-year-olds decreases, as the season progresses.[7] These ages compare favorably with those reported by Pritchard (1932) in Johnstone Strait, except that we had fewer in their fourth year.

[7] These chum salmon ages were read by Milton Lobell.

METHOD AND LOCALITY OF CAPTURE

Chum salmon are taken chiefly by purse seines in Puget Sound and the Gulf of Georgia and by gill nets in the Fraser River. Chums run so late in the fall that most of the traps close before they are abundant, and very few are taken on Swiftsure Bank, as the weather is not conducive to ocean fishing at that season The chum-salmon catches have depended as much upon economic conditions as upon abundance, usually being larger on the even-numbered years, due to the absence of pink salmon, which furnish the cheaper grades on the odd-numbered years.

The actual number of chum salmon caught in Puget Sound is shown in table 55. These figures cannot be correlated with the canned pack as large quantities of chums were sometimes bought in British Columbia. The numbers taken in adjacent Canadian waters cannot be estimated from material on hand as chums were used for canning, freezing, smoking, dry-salting, and for export in a raw state.

SEASONAL OCCURRENCE IN NORTHERN AND SOUTHERN DISTRICTS

With the chums, as with the pinks, there is a considerable difference in time of run between the northern and southern districts of Puget Sound. However, the southern pink salmon run earlier than the northern, whereas for chums the situation is reversed.

TABLE 55.—*Puget Sound chum salmon catch, 1913–34*

Year	Purse seines [1]	Traps	Other gear	Year	Purse seines [1]	Traps	Other gear
1913	445,384	159,473		1924	713,258	84,200	62,525
1914	1,431,983	254,154		1925	436,408	67,204	31,200
1915	1,280,931	177,764	127,383	1926	838,371	125,164	100,160
1916	1,852,859	191,492	146,757	1927	398,549	99,472	28,847
1917	832,922	131,804	130,289	1928	852,411	142,708	48,982
1918	799,833	173,782	182,956	1929	1,291,448	128,214	66,772
1919	1,112,404	185,292	177,395	1930	903,081	78,688	29,591
1920	541,213	111,433	30,424	1931	581,781	85,576	15,136
1921	211,198	32,414	26,581	1932	1,009,605	50,017	32,687
1922	405,905	89,427	6,898	1933	418,620	67,445	18,074
1923	528,542	74,465	34,875	1934	777,833	51,893	37,103

[1] Includes other gear in 1913 and 1914.

TABLE 56.—*Seasonal occurrence in traps of chum salmon in northern and southern districts, 1900–34*

Week ending	North of Deception Pass		South of Admiralty Head		Week ending	North of Deception Pass		South of Admiralty Head	
	Percentage	Cumulative percentage	Percentage	Cumulative percentage		Percentage	Cumulative percentage	Percentage	Cumulative percentage
May 12			0.001	0.001	Sept. 22	5.880	14.878	1.929	13.650
May 19			.001	.002	Sept. 29	10.520	25.398	5.804	19.454
May 26			.003	.005	Oct. 6	15.704	41.102	6.014	25.468
June 2	0.007	0.007	.005	.010	Oct. 13	17.387	58.489	9.011	34.479
June 9	.010	.017	.012	.022	Oct. 20	15.033	73.522	11.467	45.946
June 16	.002	.019	.011	.033	Oct. 27	14.115	87.637	13.407	59.353
June 23	.000	.019	.010	.043	Nov. 3	9.120	96.757	10.943	70.296
June 30	.015	.034	.012	.055	Nov. 10	3.244	100.001	9.075	79.371
July 7	.003	.037	.037	.092	Nov. 17			8.621	87.992
July 14	.003	.040	.046	.138	Nov. 24			4.923	92.915
July 21	.010	.050	.089	.227	Dec. 1			2.798	95.713
July 28	.035	.085	.241	.468	Dec. 8			1.645	97.358
Aug. 4	.079	.164	.635	1.103	Dec. 15			.646	98.004
Aug. 11	.332	.496	1.058	2.161	Dec. 22			1.004	99.008
Aug. 18	.691	1.187	1.506	3.667	Dec. 29			.829	99.837
Aug. 25	1.146	2.333	2.221	5.888	Jan. 5			.099	99.936
Sept. 1	1.442	3.775	2.031	7.919	Jan. 12			.022	99.958
Sept. 8	1.880	5.655	2.026	9.945	Jan. 19			.009	99.967
Sept. 15	3.343	8.998	1.776	11.721	Feb. 23			.031	99.998

For the district north of Deception Pass, data were analyzed for seven traps catching 124,831 fish from 1902–34. For the district south of Admiralty Head, the six traps used caught 821,263 chums from 1900–1934.

In the northern district the run really commences about the middle of September and reaches its peak by October 10. In the southern district there is a small early run in late August and early September, but the main run does not really start until nearly the end of September, and the peak is not reached until October 24, just 2 weeks later than the northern run.

Because of the difference in time of run in the 2 districts, only a small fraction of the northern chums are protected by the closed season commencing November 11. This same closing date, however, protects about 20 percent of the southern run.

ABUNDANCE FROM ADMIRALTY INLET TRAPS

For the chum-trap index, 8 Admiralty Inlet traps were employed, 3 each from the Admiralty Bay and Bush Point areas, and 1 each from the Oak Bay and Point No Point areas. The total catch of each trap up to and including November 3 was used, as this period normally includes 70 percent of the southern run and it was not feasible to use a longer period as many of the traps ceased fishing by that date. In 1934, 1921, and 1920 they all closed too early to be usable. The index was calculated in the same manner as that described for sockeyes. Three traps, over a 19-year period, were used for the standard curve.

Because a small number of traps were used, and only a portion of the run occurred during the period they fished, the index is not especially reliable for any particular year. However, it does show that the chums of the southern district were very abundant at one time. In the last 12 years they were less than half as abundant as during the period just previous to the war (see table 57).

ABUNDANCE FROM PURSE SEINES

An estimate of the abundance of chums was made from the Puget Sound seine catches. The average catch per weighted delivery, each delivery was weighted by the efficiency weight given in the purse-seine section of this report, was first obtained for a 6-week period from September 23–November 3. From 1910–34 data were available for 25,838 deliveries containing 5,322,546 chums.

The first 2 weeks of the 6-week period chosen represented a large number of catches but only a few chums, the run having not yet attained any proportions. The efforts of the fleet up to this time had been almost wholly directed toward the capture of cohos. For this reason the average delivery was also obtained for a 4-week period from October 7–November 3, which, over the 25 years, represented 19,584 catches and 4,973,971 fish (see table 58).

The average catch per delivery obtained from the purse seine data appears to reflect economic factors as well as abundance. Thus 11 out of 12 of the even-numbered years are higher than the year preceding them, whereas 8 out of 12 of the odd-numbered years are lower than the preceding year. Since the chums vary from 3–5 years in age at maturity, there is no apparent biological reason for a higher level of abundance in the even years.

TABLE 57.—*Chum index of abundance for Admiralty Inlet traps, 1902–33*

Year	Catches	Efficiency weights	Number of traps	Index of abundance	Index from standard curve
1902	21,952	15,324	2	143.252	
1903					
1904	36,589	34,921	4	104.776	118.043
1905	34,911	15,324	2	227.819	
1906	19,068	33,988	2	56.102	
1907	26,221	24,586	3	106.650	106.650
1908	86,368	24,586	3	351.289	351.289
1909	94,885	41,906	4	226.423	207.435
1910	67,474	41,906	4	161.013	155.483
1911	48,357	41,906	4	115.394	155.829
1912	24,777	18,503	2	133.908	
1913	31,730	24,586	3	129.057	129.057
1914	32,629	41,906	4	77.862	83.238
1915	26,690	24,586	3	108.558	108.558
1916	35,209	48,336	5	72.842	68.592
1917	31,578	48,336	5	65.330	65.907
1918	28,815	29,833	3	96.588	
1919					
1920					
1921					
1922	8,871	24,992	2	35.495	
1923	22,897	56,660	6	40.411	36.094
1924	29,604	50,577	5	58.533	
1925	13,809	56,660	6	24.372	17.929
1926	34,565	56,660	6	61.004	70.630
1927	26,439	50,327	6	52.534	55.349
1928	24,539	50,327	6	48.759	62.637
1929	45,843	67,647	7	67.768	61.962
1930	20,883	67,647	7	30.871	19.556
1931	21,346	34,737	3	61.450	
1932	9,626	18,659	2	51.589	
1933	24,275	59,323	6	40.920	38.062
Total	929,950				

TABLE 58.—*Chum-salmon index of abundance from Puget Sound purse seines*

Year	From September 23–November 3				From October 7–November 3			
	Number of fish	Number of catches	Weighted number of catches	Average catch	Number of fish	Number of catches	Weighted number of catches	Average catch
1910	7,211	20	18.40	391.90	7,211	20	183.40	391.90
1911	42,190	111	103.24	408.66	42,190	111	103.24	408.66
1912	88,268	163	155.44	567.86	86,156	124	117.56	732.87
1913	37,612	174	199.78	188.27	36,851	163	187.34	196.71
1914	169,628	360	405.10	418.73	154,475	261	295.26	523.18
1915	129,855	620	779.38	166.61	121,178	461	576.84	210.07
1916	157,217	665	786.90	199.79	151,755	520	614.76	246.85
1917	190,120	1,471	1,838.92	103.39	186,042	1,330	1,659.78	112.09
1918	149,824	749	973.54	153.90	140,178	598	764.04	183.47
1919	174,512	753	963.04	181.21	154,926	551	709.50	218.36
1920	76,038	298	394.04	192.97	70,043	217	283.18	247.34
1921	48,546	688	1,004.46	48.33	40,606	383	551.74	73.60
1922	79,111	552	761.30	103.92	71,675	412	541.50	132.36
1923	146,388	671	971.16	150.74	136,875	526	759.82	180.14
1924	176,332	490	640.26	275.41	157,939	376	486.74	324.48
1925	117,305	817	1,102.88	106.36	111,886	672	901.16	124.16
1926	285,644	1,116	1,698.14	168.21	258,216	758	1,149.84	224.57
1927	95,651	1,061	1,581.94	60.46	88,328	766	1,122.44	78.69
1928	462,882	2,004	3,134.97	147.65	441,033	1,511	2,378.50	185.42
1929	725,733	2,527	3,766.80	192.67	674,788	1,858	2,721.71	247.93
1930	342,117	1,167	1,904.25	179.66	327,533	695	1,146.29	285.73
1931	335,268	2,061	3,314.75	101.14	319,927	1,596	2,538.51	126.03
1932	693,046	2,528	4,140.78	167.37	648,097	1,931	3,113.67	208.15
1933	230,945	2,519	4,013.42	57.54	215,860	1,988	3,168.02	68.14
1934	361,103	2,253	3,425.82	105.41	330,203	1,756	2,651.12	124.55

There is usually a greater demand for chums in the even-numbered years, owing to the lack of pinks, and the deliveries are raised by increased effort on the part of the

fishermen. Another factor may be lessened competition between gear on the even years, as usually there is a smaller fall fleet than on the odd years.

All that can safely be said is that the purse-seine data seem to indicate that the general trend has remained about the same since 1915. Before that the data are scant but seem to indicate a higher level of abundance.

SUMMARY

By George A. Rounsefell and George B. Kelez

THE GILL-NET FISHERY

On the Fraser River sockeye salmon was at first used to the practical exclusion of other species, but in later years the fishery was extended to include the others. Drift gill nets, introduced in 1864, have been the only gear used there. The fishery developed rapidly and the number of canneries increased steadily, reaching maxima of 49 plants in 1898 and in 1901; mergers and decreasing runs caused many of the plants to be closed thereafter. Less than a dozen have operated in any year since 1921.

The Fraser River gill nets were at first fished mainly by Indians, later more white fishermen were engaged, and Japanese fishermen were introduced on the river in 1888. The early flat-bottomed skiffs were replaced in the 1890's by round-bottomed Columbia River boats, which were generally equipped with engines by about 1914. Each of these changes increased the efficiency of the individual units of gear. The number of gill nets licensed on the river reached a peak of more than 3,600 in 1900, but decreased considerably within a few years, until at the present time about half that number are employed.

Regulations, some in effect since 1878, have limited the size and the mesh of gill nets, and have provided for a week-end closed season intended to permit escapement of salmon up the Fraser River.

The sockeye, pink, and chum salmon overlap but slightly, in their seasonal occurrence on the Fraser River, but the runs of coho and king salmon are more extended. The bulk of the sockeye catches have been made between July 22 and August 25, those of the pinks, which are abundant only in odd-numbered years, between September 2 and September 29, and of the chums between October 7 and November 10. The major catch of cohoes is made between September 9 and October 13, that of the kings between July 1 and September 15.

Gill nets are of minor importance on Puget Sound, where they are used chiefly in or adjacent to the estuaries of the larger Puget Sound rivers, catching mainly coho and king salmon.

THE TRAP FISHERY

Salmon traps were driven in Puget Sound as early as 1880, but were not developed to a point of success until about 1891, at which time the first sockeye cannery was built on Puget Sound. This success caused a great expansion of the American fishery, and 163 traps were driven by 1900. The peak year for traps was 1913, when 168 were driven on Puget Sound, 2 in the Canadian waters of Boundary Bay, and 6 near Sooke on Vancouver Island. Available data show that between 1895 and 1934, over 156,-

000,000 salmon were taken by traps, 53 percent of which were caught in the waters north of Sandy Point, 27 percent in the region of the San Juan Islands, 4 percent on the west shore of Whidbey Island, north of Point Wilson, 5 percent west of Point Wilson, and 11 percent in areas south and east of Point Wilson.

In the period from about 1900–1934 the average number of days of operation of each trap has increased from 46–95 days in Boundary Bay, and in Admiralty Inlet the time at which they commence operations has advanced 85 days.

The average seasonal occurrence of each species of salmon is quite distinct in the trap catches. Kings run very early, 40 percent of the catch being made by June 30. They are followed by the sockeyes, whose run is practically over by August 25, at which date only 40 percent of the pinks have been taken. The latter species reaches a peak about August 29, the cohos about October 1 and the chums about October 23.

THE PURSE-SEINE FISHERY

Purse seines were used in this region before 1882, and within a decade had become the most important type of gear on Puget Sound. Later they were surpassed by the traps, but the introduction of the gasoline engine, completed by 1907, returned them to a place of considerable consequence in the fishery.

The purse-seine vessels have improved steadily in design and equipment, and have increased in size throughout the history of this fishery. The average efficiency of the fleets has correspondingly increased so that, although the modern fleet is smaller in numbers than were those of many earlier years, the total fishing efficiency of today is greater than in all but 1 previous year.

Both fishing season and the size of the fleets vary considerably in odd- and even-numbered years. The summer fishery is most important in the odd-numbered years, when pink salmon are abundant, while the fall fishery for cohoes and chums is considerably greater in even years. The number of vessels fishing is usually greater in odd than in even years. The larger vessels fish on the high seas in spring and early summer, moving into Puget Sound later in the season.

Seasonal occurrence of the various species in purse-seine catches is similar to that in trap catches, but the periods of abundance are more prolonged. From 1917–34, pink salmon have averaged 75 percent of the catch in odd years, but less than 1 percent in even years. Over this 18-year period their average was 37.44 percent of the catch, chums were 32.07 percent, sockeyes 15.63 percent, cohoes 14.16 percent, and kings 0.70 percent.

The proportion of pink salmon in odd and even years at the cape is similar to that on Puget Sound. During the period from 1927–34, pinks averaged 46.54 percent of the cape catches, cohoes were 36.83 percent, and sockeyes 14.84 percent. Chums and kings both averaged less than 1.0 percent.

THE TROLL FISHERY

Coho and king salmon provide almost the entire catch of the troll fishery, which was of slight consequence until the introduction of engines increased the efficiency of the boats. During recent years almost the entire troll fleet has fished at the cape,

the season extending from April to October. Over the 8-year period from 1927–34, Puget Sound trollers took 104,692 cohos and 18,285 kings, while the cape fleet took 2,411,312 cohos and 1,545,178 kings.

SOCKEYE SALMON

The Fraser River produces the only sockeye run of consequence in the region. From 1873–1934, over 250 million sockeyes have been canned, of which 46 percent were taken by Fraser River gill nets, 37 percent by traps, 14 percent by purse seines, and 3 percent by miscellaneous gear. An analysis of seasonal occurrence from gill-net catches indicates that the heavy, early-season run of superior quality sockeyes has suffered the greatest decrease in abundance. Indices of abundance from gill-net and trap catches both show a tremendous decline in all cycles.

The cycle of years ending in 1934 fell about 39 percent in abundance between 1898 and 1914, reached a very low point in 1918, and has been increasing considerably in each cycle after that date.

The big year cycle, 1933, etc., tremendously abundant in early years, was severely reduced by over fishing and the Hell's Gate slide, but has recuperated slightly in recent years.

The cycle of years containing 1932 was the least abundant in the early years of the fishery, and declined still further in 1904. The run of 1932 was the best since that of 1912.

The cycle of years containing 1931 has been the least abundant since 1899, although it was second in abundance for several years preceding that date.

COHO SALMON

Cohoes are the most widely distributed species of salmon found in the region. Approximately 98 percent mature at 3 years of age, and the migration to the spawning beds occurs during the fall months, at which period the greater part of the catch is made. During the 9 years from 1926–34, approximately 5½ million cohoes were taken on the high seas, a slightly greater number in Puget Sound waters, and about one-half million in the Fraser River. The greater part of the Puget Sound catches are taken in the southern part of that district. Seasonal occurrence is generally earlier in the northern than in the southern districts. Indices of abundance from both trap and purse seine catches show a high level of abundance in early years and a present level that is lower than at any previous time in the history of the fishery.

KING SALMON

King salmon are caught from early spring to fall, the bulk of the catches being made during early summer. During the 8 years from 1927–34, nearly 4 million were landed in the region, of which trollers landed approximately 40 percent, traps 39 percent, gill nets 15 percent, and purse seines and miscellaneous gear 6 percent. Indices of abundance from trap catches do not show any definite trends in the northern areas, but do indicate a decrease in the runs of recent years in the southern part of Puget Sound.

71941—38——9

PINK SALMON

In the 10-year period from 1925–34, the pink salmon catch in the region was more than 50,000,000 fish, of which 60 percent were taken by purse seines, 27 percent by traps, 12 percent by Fraser River gill nets, and 2 percent by minor gear. Of the trap-caught fish, taken between 1895 and 1934, about 5 times as great a catch was made north of Deception Pass as south of that point. The peak of the seasonal runs in the southern part of Puget Sound is about 10 days earlier than in the northern part. Indices of abundance from purse seines and traps indicate that, following the obstruction at Hell's Gate in 1913, which prevented them from reaching their spawning grounds in the upper Fraser River, the pinks declined to about one-quarter of their former abundance.

CHUM SALMON

The runs of chum salmon occur during the last part of the fishing season, and have been taken chiefly by purse seines in the Puget Sound district, as most of the traps have ceased fishing by the time that the runs appear in any quantity. The chums of Admiralty Inlet were found to be approximately 38 percent 3-year-olds, 53 percent 4-year-olds, and 9 percent 5-year-olds at maturity. The peak of the runs in the northern part of Puget Sound occurs about 2 weeks earlier than in the southern part. An index of abundance from Admiralty Inlet traps shows abundance in recent years to be less than half that of the period previous to the war. The average size of delivery by purse seines also indicates a higher level of abundance previous to 1915.

BIBLIOGRAPHY

Babcock, John P. 1902–1932. The spawning-beds of the Fraser River. In annual reports of the Commissioner of Fisheries (British Columbia) for the years 1901–1931. Victoria.

Babcock, John P. 1918. Salmon-fishery of the Fraser River district. Appendix to the report of the Commissioner of Fisheries (British Columbia) for the year ending December 31, 1917, pp. Q 116–Q 123. Victoria.

Babcock, John P. 1920. The Fraser River salmon situation. Canada's position. Canadian Fisherman, vol. VII, No. 6, pp. 101–104.

British Columbia Commissioner of Fisheries. 1901–1934. Annual reports of the Commissioner of Fisheries (British Columbia) and Appendices. Victoria.

Clemens, Wilbert A. 1930. Pacific salmon migration: The tagging of the Coho salmon on the east coast of Vancouver Island in 1927 and 1928. Biological Board of Canada, Bulletin 15, pp. 1–19, 1930. Toronto.

Clemens, Wilbert A. 1932. Pacific salmon migration: The tagging of the spring salmon on the east coast of Vancouver Island in 1927 and 1928 with notes on incidental tagging of other fish. Biological Board of Canada, Bulletin 27. Ottawa.

Clemens, Wilbert A. 1935. The Pacific salmon in British Columbia waters. Report of the Commissioner of Fisheries (British Columbia) for 1934, pp. K 103–K 105. Victoria.

Clemens, Wilbert A. and Lucy S. 1926–1934. Contributions to the life history of the sockeye salmon. Appendices to the annual reports of the Commissioner of Fisheries (British Columbia). Victoria.

Cobb, John N. 1911. The salmon fisheries of the Pacific coast. U. S. Bureau of Fisheries Document No. 751. Appendix to the report of the U. S. Commissioner of Fisheries for 1910. 180 pages. Washington.

Cobb, John N. 1930. Pacific salmon fisheries. Bureau of Fisheries Document 1092. Appendix XIII to the report of the U. S. Commissioner of Fisheries for 1930. 4th edition, pp. 409–704. Washington.

COLLINS, J. W. 1892. Report on the fisheries of the Pacific coast of the United States. Report U. S. Fish Commission for 1888, pp. 3–269, Fisheries of Puget Sound, pp. 243–269. Washington.

CRAWFORD, JOHN M. 1902. (Letter to the State Fish Commissioner.) 13th annual report of the State Fish Commissioner (Washington), pp. 10–15. Seattle.

DAVIDSON, FREDERICK A. 1934. The homing instinct and age at maturity of pink salmon (*Oncorhynchus gorbuscha*). Bulletin, United States Bureau of Fisheries, vol. XLVIII, 1933 (1934) pp. 27–39. Washington.

DOMINION OF CANADA 1882–1891. Annual reports of the Dept. of Fisheries of Canada.

DOMINION OF CANADA 1892–1914. Annual reports of the Dept. of Marine and Fisheries of Canada.

DOMINION OF CANADA 1915–1919. Annual reports of the Naval Service (Canada).

DOMINION OF CANADA 1920–1930. Annual reports of the Dept. of Marine and Fisheries of Canada, Fisheries Branch.

DOMINION OF CANADA 1931–1934. Annual reports of the Dept. of Fisheries of Canada.

DOMINION OF CANADA 1927–1934. Fisheries Statistics of Canada. Fisheries Statistics Branch. Dominion Bureau of Statistics.

DOYLE, HENRY. 1920. History of the Pacific coast salmon industry. Canadian Fisherman, vol. VII, No. 6, pp. 72–74.

FOERSTER, R. EARLE. 1929. An investigation of the life history and propagation of the sockeye salmon (*Oncorhynchus nerka*) at Cultus Lake, British Columbia. No. 1. Introduction and the run of 1925. Contributions to Canadian Biology and Fisheries, New Series, vol. V, No. 1, 1929. Toronto.

FOERSTER, R. EARLE. 1929. An investigation of the life history and propagation of the sockeye salmon (*Oncorhynchus nerka*) at Cultus Lake, British Columbia. No. 3. The down-stream migration of the young in 1926 and 1927. Contributions to Canadian Biology and Fisheries, New Series, vol. V. No. 3, 1929. Toronto.

FOERSTER, R. EARLE. 1934. An investigation of the life history and propagation of the sockeye salmon (*Oncorhynchus nerka*) at Cultus Lake, British Columbia. No. 4. The life history cycle of the 1925 year class with natural propagation. Contributions to Canadian Biology and Fisheries, vol. VIII, No. 27 (Series A, General, No. 42). Toronto.

FRASER, C. MCLEAN. 1917a. On the scales of the spring salmon. Contributions to Canadian Biology for 1915–1916, pp. 21–38. Ottawa.

FRASER, C. MCLEAN. 1917a. On the life-history of the coho. Contributions to Canadian Biology for 1915–16, pp. 39–52. Ottawa.

FRASER, C. MCLEAN. 1920. Growth rate in the Pacific salmon. Transactions Royal Society of Canada, Series III, vol. XIII, for 1919, Sect. V, pp. 163–226. Ottawa.

FRASER, C. MCLEAN. 1921. Further studies on the growth rate in Pacific salmon. Contribution to Canadian Biology, 1918–1920, pp. 7–27. Ottawa.

GILBERT, CHARLES H. 1912. Age at maturity of the Pacific Coast salmon of the genus Oncorhynchus. Bulletin, United States Bureau of Fisheries, vol. XXXII, pp. 1–22. Washington.

GILBERT, CHARLES H. 1913. The salmon of Swiftsure Bank. Appendix to the report of the Commissioner of Fisheries (British Columbia) for the year ending December 31, 1912, pp. I 14–I 18. Victoria.

GILBERT, CHARLES H. 1913–1924. Contribution to the life history of the sockeye salmon. (1–10.) Reports of the British Columbia Commissioner of Fisheries for the years 1913–15, 1917–19, 1921–24. Victoria.

GILBERT, CHARLES H. 1923. The salmon of the Yukon River. Bulletin, U. S. Bureau of Fisheries for 1921–22, vol. XXXVIII, pp. 317–332. Washington.

GREENWOOD, W. H. 1917. The salmon fishermen. Canadian Fishermen, July 1917, pp. 288–290 292–294.

HITTELL, JOHN S. 1882. Commerce and Industries of the Pacific Coast. Bancroft & Co. San Francisco.

HOWAY, F. W. 1914. British Columbia, from the earliest times to the present. 4 vols., illus. Vancouver.

MORICE, A. G. 1904. The history of the northern interior of British Columbia, formerly New Caledonia (1660–1880), 349 pages. Toronto.

MOTTLEY, CHAS. McC. 1929. Pacific salmon migration. Report on the study of the scales of the spring salmon tagged in 1926 and 1927 off the west coast of Vancouver Island. Contributions to Canadian Biology and Fisheries, N. S., vol. 4, No. 30, 1929.

MYERS, GEORGE T. 1905. Early canning days on Puget Sound. Pacific Fisherman Annual, January 1905. pp. 25–6. Seattle.

O'MALLEY, HENRY and WILLIS H. RICH. 1919. Migration of adult sockeye salmon in Puget Sound and Fraser River. U. S. Bureau of Fisheries Document 873. Appendix VIII to the report of the United States Commissioner of Fisheries for 1918. pp. 1–38. Washington.

PACIFIC FISHERMAN. 1904–1933. Pacific Fisherman Annuals. Seattle, Wash.

PRITCHARD. ANDREW L. 1930. Pacific salmon migration: The tagging of the pink salmon and the chum salmon in British Columbia in 1928. Biological Board of Canada, Bulletin 14. Toronto.

PRITCHARD, ANDREW L. 1932. Pacific salmon migration: The tagging of the pink salmon and the chum salmon in British Columbia in 1929 and 1930. Biological Board of Canada, Bulletin 31, 1932. Ottawa.

PRITCHARD, ANDREW L. 1934. Pacific salmon migration: The tagging of the coho salmon in British Columbia in 1929 and 1930. Biological Board of Canada, Bulletin 40, 1934. Ottawa.

PRITCHARD, ANDREW L. 1934. Pacific salmon migration: The tagging of the spring salmon in British Columbia in 1929 and 1930. Biological Board of Canada, Bulletin 41, 1934. Ottawa.

PRITCHARD, ANDREW L. 1934. The recovery of marked pink salmon in 1934. Biological Board of Canada. Progress reports of Pacific Biological Station, Nanaimo, B. C. and Pacific Fisheries Experimental Station, Prince Rupert, B. C., No. 22, pp. 17–18. Prince Rupert.

PRITCHARD, ANDREW L. 1936. Facts concerning the coho salmon (*Oncorhynchus kisutch*) in the commercial catches of British Columbia as determined from their scales. Progress reports of Pacific Biological Station, Nanaimo, B. C. and Pacific Fisheries Experimental Station, Prince Rupert, B. C., No. 29, pp. 16–20. Prince Rupert.

RATHBUN, RICHARD. 1899. A review of the fisheries in the contiguous waters of the State of Washington and British Columbia. Report U. S. Fish Commission for 1899, pp. 251–350, plates. Washington.

RICH, WILLIS H. 1925. Growth and degree of maturity of chinook salmon in the ocean. Bulletin, United States Bureau of Fisheries, vol. XLI, pp. 15–90. Washington.

RICH, WILLIS H., and EDWARD M. BALL. 1928. Statistical review of the Alaska salmon fisheries. Part I: Bristol Bay and the Alaska Peninsula. Bulletin, United States Bureau of Fisheries, vol. XLIV, pp. 41–95. Washington.

RICH, WILLIS H., and EDWARD M. BALL. 1931. Statistical review of the Alaska salmon fisheries. Part II: Chignik to Resurrection Bay. Bulletin, United States Bureau of Fisheries, vol. XLIV, 1930, pp. 643–712. Washington.

RICH, WILLIS H., and H. B. HOLMES. 1928. Experiments in marking young chinook salmon on the Columbia River, 1916–1927. Bulletin, United States Bureau of Fisheries, vol. XLIV, pp. 215–264. Washington.

SMITH, E. VICTOR. 1921. The taking of immature salmon in the waters of the State of Washington. The taking of immature salmon in the waters of the State of Washington during the 1920 fishing season. The thirtieth and thirty-first annual reports of the State Fish Commission (Washington). Olympia.

UNITED STATES BUREAU OF FISHERIES 1925–1934. Fishery industries of the United States. Appendices to the reports of the U. S. Commissioner of Fisheries for 1925–1934. Washington.

MCLEAN, JOHN (Wallace, W. S. ed.). 1932. Notes of a twenty-five year's service in the Hudson's Bay Territory. The Champlain Society, Toronto. 1932.

WASHINGTON STATE 1890–1920. Annual reports of the State Fish Commissioner.

WASHINGTON STATE 1921–1926. Annual reports of the State Supervisor of Fisheries.

WASHINGTON STATE 1927–1930. Annual reports of the Division of Fisheries, State Department of Fisheries and Game.

WASHINGTON STATE 1931–1934. Annual reports of the State Department of Fisheries.

WILCOX, WILLIAM A. 1895. Fisheries of the Pacific Coast. Appendix to the report of the Commissioner, U. S. Fish Commission for 1893, pp. 139–304.

WILCOX, WILLIAM A. 1898. Notes on the fisheries of the Pacific Coast in 1895. Appendix to the report of the Commissioner, U. S. Fish Commission for 1896, pp. 575–659.

WILCOX, WILLIAM A. 1902. Notes on the fisheries of the Pacific coast in 1899. Appendix to the report of the Commissioner, U. S. Fish Commission for 1901, pp. 501–574.

WILCOX, WILLIAM A. 1907. The commercial fisheries of the Pacific Coast States in 1904. U. S. Bureau of Fisheries Document No. 612, 74 p. Washington. Report of Com. for 1905. Special paper.

WILLIAMSON, H. CHAS. 1927. Pacific salmon migration: Report on the tagging operations in 1925. Contr. Canad. Biol. Fish, N. S., vol. 3, No. 9.

WILLIAMSON, H. CHAS. 1929. Pacific salmon migration: Report on the tagging operations in 1926, with additional returns from the operations of 1925. Contributions to Canadian Biology and Fisheries, N. S. vol. 4, No. 29.

WILLIAMSON, H. CHARLES and WILBERT A. CLEMENS. 1932. Pacific salmon migration: The tagging operations at Quatsino and Kyuquot in 1927, with additional returns from the operations of 1925 and 1926. Biological Board of Canada, Bulletin 26. Ottawa.

○